NATURAL RESOURCES AND THE ENVIRONMENT

Research in the area of natural resources and the environment addresses contemporary issues important for agriculture and for society. Knowledge in diverse scientific disciplines is needed in order to understand the influence of environmental fluctuations, to foster sustainability and economic viability, and to enhance stewardship of natural resources and agriculturally important ecosystems. Program Areas in this Division include: Plant Responses to the Environment; Forest/Rangeland/Crop/Aquatic Ecosystems; Soils and Soil Biology; and Water Resources Assessment and Protection. The Natural Resources and Environment Division also provides funding for the Improved Utilization of Wood and Wood Fiber Program; abstracts for this program can be found in the Enhancing Value and Use of Agricultural and Forest Products Division section.

PLANT RESPONSES TO THE ENVIRONMENT

Panel Manager - Dr. David Rhodes, Purdue University
Program Director - Dr. Anne H. Datko

Awards in this area support research aimed at understanding the plant's response to environmental factors, both natural and anthropogenic. The major goal of the program is to provide the basic knowledge needed for devising strategies for decreasing the impact of environmental stress and for adapting agricultural and forest practices to possible changes predicted to accompany global climate fluctuations.

Studies on mechanisms at the whole plant, cellular or molecular level which explain organismal response are emphasized. The environmental factors of interest include water, temperature, light (including UV-B), nutrient, and atmospheric chemical composition (including carbon dioxide and other greenhouse gases, sulfur dioxide and ozone).

9700605 Significance of UV-induced Autofluorescence in Leaves
Day, T.A.; Clark, W.D. **Grant 97-35100-4212**

Arizona State University
Department of Botany **$160,000**
Tempe, AZ 85287-1601 **3 Years**

Leaves have several mechanisms which protect them from potential damage by ultraviolet radiation (UV), including the production of UV-absorbing compounds which screen much UV before it reaches sensitive targets inside the leaf. Many of these screening compounds not only absorb UV but also emit visible light upon absorbing UV. This process, termed autofluorescence, has received very little attention, but has important implications because visible light is used by leaves in several important processes such as photosynthesis. Thus, these screening compounds may provide visible light, which can improve photosynthetic rates and growth. In a preliminary investigation, we found that UV-induced autofluorescence appeared responsible for increasing leaf photosynthetic rates by 5-10 % when leaves were receiving nonsaturating or limiting levels of visible light. Our research will examine the significance of UV-induced autofluorescence in leaves by: (1) examining how widespread this autofluorescence is in different plant species, (2) characterizing the contribution of this autofluorescence to internal visible light levels within leaves, (3) identifying the compounds responsible for this autofluorescence, and (4) quantifying the contribution of this autofluorescence to photosynthesis. Should this process appear to be significant in improving photosynthesis and plant growth, the potential for manipulating it in crops appears realistic since plant breeders have been successful in developing cultivars with higher concentrations of phenolic compounds, and these compounds are probably the major UV-induced autofluorescent compounds in leaves.

9700543 Water Channel Protein Expression and Activity
Bohnert, H.J. **Grant 97-35100-4337**

University of Arizona
Departments of Biochemistry, Plant Sciences, Molecular & Cellular Biology **$110,700**
Tucson, AZ 85721-0088 **2 Years**

The interest of the laboratory is in defining the mechanisms which enable some plants to tolerate drought conditions and high salinity in the soil. Both these typical plant stresses induce water deficit and are agronomically relevant. Several mechanisms have been identified by us and a number of other laboratories. The mechanism on which we plan to focus is the control over the entry of water into root cells and the regulation of water flow towards aerial tissues. We have isolated genes for several water channel proteins that control or are involved in the control of water flux. Antibodies against these proteins indicate that each of the proteins is located in particular cell types of the root and in cells of the water transmitting "conduits," e.g., the xylem and xylem-associated cells inside root, stem and leaf tissue. Water channel protein expression changes during salt stress and drought episodes. We will monitor the changes. Specific emphasis will be on the synthesis of water channel proteins and their location in membranes. The hypothesis to be tested is that water channel proteins are removed from membranes in salt-tolerant plants while they persist in salt-sensitive plants, which then lose water to the outside. We are interested in how this process is regulated in the two types of plants.

9700711 Why Is the S0S3 Locus Essential for Plant Salt Tolerance and Potassium Nutrition?
Zhu, J.K. **Grant 97-35100-4850**

University of Arizona
Department of Plant Sciences **$168,800**
Tucson, AZ 85721 **3 Years**

The objective of this research is to understand the mechanism of salt tolerance in plants. Previous work has identified three salt overly sensitive (SOS) genetic loci, *SOS1*, *SOS2* and *SOS3*, that are essential for salt tolerance in the model plant *Arabidopsis thaliana*. Mutations in these genes render the plants hypersensitive to salt stress and unable to grow on low potassium culture medium. The *SOS3* locus is especially interesting because increased extracellular calcium can suppress the *sos3* mutant phenotype. In order to understand the molecular basis of *SOS3* function, this gene will be isolated by positional cloning. Positional or map-based cloning requires 1) isolating a bacterial artificial chromosome (BAC) clone that contains the *SOS3* locus , 2) subcloning the BAC insert into overlapping cosmids, 3) identifying cosmid clones that complement the *sos3* mutant phenotype, and 4) isolating and sequencing cDNA and genomic clones corresponding to the *SOS3* gene. Isolation of a key salt tolerance gene such as *SOS3* should facilitate genetic improvement of salt tolerance in crop plants.

9700801 Polyamine Regulation of Ion Channels in Guard Cells
Luan, S. **Grant 97-35100-4190**

University of California, Berkeley
Department of Plant and Microbial Biology **$168,800**
Berkeley, CA 94720 **3 Years**

Plants are constantly bombarded by environmental factors such as light, temperature, and moisture. Some extreme conditions may significantly alter plant development and cause reduction of crop yields. Our long term goal is to understand how plants cope with environmental stresses and provide mechanisms to improve crop tolerance to the stress conditions. A number of studies have shown that polyamine levels in plants increase dramatically upon many environmental stresses. Our preliminary studies suggest that polyamines may serve as a chemical messenger for stress signals and further regulate cellular processes. In particular, natural polyamine levels significantly affect the aperture of stomatal pores that are also very sensitive to environmental stresses. As a step to understanding polyamine action, we have found polyamine-regulated ion channels in guard cells that are key components in stomatal regulation. This finding links polyamine levels to stomatal regulation and provides the first evidence that polyamines are involved in ion channel regulation in higher plants. Combining techniques in electrophysiology and molecular biology, the proposed research will focus on the mechanism underlying polyamine regulation of ion channels in guard cells. These studies will increase understanding of stress signal transduction and provide information for engineering stress-tolerant crops.

9700552 Mechanisms that Determine Selective Translation of mRNA in Oxygen-Deprived Roots
Bailey-Serres, J. **Grant 97-35100-4191**

University of California, Riverside
Botany and Plant Sciences Department **$168,800**
Riverside, CA 92521-0217 **3 Years**

Flooding of crops is a major cause of reduced yield. Flooding dramatically decreases the level of oxygen necessary for efficient production of cellular energy by non-green organs such as roots. Certain plants survive transient flooding if it occurs gradually and at an early developmental age. We study responses of crops to flooding at the gene level with the aim to improve flood-tolerance. The flooding of roots of corn seedlings switches on genes that encode proteins that increase energy production in the absence of oxygen. This increase in anaerobic metabolism improves survival of short-term flooding. Our investigations have shown that genes that encode normal cellular proteins stayed switched on in flooded cells but the proteins these genes encode are not made. This selective synthesis of proteins involved in anaerobic metabolism and inhibition of synthesis of proteins involved in other normal cellular processes is a key control mechanism in the response to flooding. We have shown that specific regions of gene messages are required for the selective synthesis of a protein under low-oxygen. We will study the cellular machinery that selects gene messages for synthesis of protein in corn roots. The proposed experiments will address the molecular mechanisms of low-oxygen perception that are transmitted to the machinery that synthesizes proteins. These analyses will provide information on the fundamental mechanisms that highly regulate the synthesis of specific proteins in response to environmental cues.

9701063 The Effects of Uptake and Assimilation of the Air Pollutant Nitric Acid on Forest Trees
Bytnerowicz, A. **Grant 97-35100-4402**

USDA Forest Service
Pacific Southwest Research Station **$110,700**
Riverside, CA 92507-0000 **2 Years**

Effects of atmospheric deposition of nitrogenous (N) pollutants on biological systems in the western United States are not well understood. This is despite the importance of western forests as a major component of our natural resources and substantial contributors to the national and local economy. Over large areas of California summer atmospheric dry deposition is of greater magnitude than winter wet deposition of airborne N compounds. This is due to the Mediterranean climate and persistent presence of photochemical smog caused by thermal inversions. Forests around the Los Angeles Basin have been in decline since the l960s. Most of the atmospheric N deposition in the southern California occurs as nitric acid vapor (HNO_3). Due to its high deposition velocity and relatively high concentrations, nitric acid is an important source of N in these forests. Very little is known about the physiological effects of HNO_3 on forest tree species and its potential phytotoxicity. Our preliminary short-term fumigation experiments of *Pinus ponderosa* and *Quercus kelloggii* indicated that HNO_3 deposited on leaf surfaces is readily absorbed and assimilated. This resulted in an overall increase in tissue total N and nitrate and increased nitrate reductase activity and free amino acid concentrations in foliage and roots. Also carbohydrate metabolism of *Q. kelloggi* was affected by the HNO_3 exposures--leaf starch concentrations increased and soluble sugar levels decreased compared to control trees. We propose a detailed investigation of the effects of HNO_3 vapor on four different tree species common to the western mixed conifer forest (*Pinus ponderosa, Quercus kelloggii, Quercus chrysolepsis and Abies concolor).* Tree seedlings will be exposed to controlled elevated levels of $H^{15}NO_3$ in continuously stirred tank reactors. Deposition, foliar injury, foliar gas exchange, N and C metabolism will be investigated. Results of this study will show if the observed changes lead to impairment of survival of trees in the semi-arid ecosystems of California. We postulate that nitric acid is a contributing factor in forest decline leading to increased sensitivity of trees to other stresses, e.g., ozone, drought or insect attacks. In addition, while the initial increased N availability due to HNO_3 deposition can enhance growth of plants, chronic HNO_3 exposures may lead to N saturation and decline of forest health.

9700718 Production of Phenolic Antioxidants in Response to Environmental Stress
Grace, S.C. **Grant 97-35100-4390**

University of Colorado **New Investigator Award**
Department of Environmental, Population and Organismic Biology **$92,000**
Boulder, CO 80309-0334 **2 Years**

Many types of environmental stress cause an increase in the production of phenolic secondary compounds in plants. One such compound is chlorogenic acid, a major product of the plant phenylpropanoid pathway. Despite its natural abundance, the biochemical function of chlorogenic acid in plants is unknown. Recent pharmacological studies have revealed that chlorogenic acid and related plant diphenols possess powerful hydrogen donating (antioxidant) properties against a variety of oxidizing and potentially harmful free radicals. Yet there has been little investigation of whether these compounds function as antioxidants within plants themselves. This question has been the subject of recent research into the mechanisms of stress tolerance in the evergreen shrub *Mahonia repens*. Leaves of this species produce large amounts of chlorogenic acid when exposed to the combined environmental stresses of high light intensity and low temperature, whereas plants growing under deeply shaded conditions maintain low and nearly constant levels of chlorogenic acid throughout the year. More importantly, the ability of *Mahonia* leaf extracts to neutralize a range of oxidizing free radicals correlated directly with chlorogenic acid concentration, supporting an antioxidant role for this metabolite. The major aim of the proposed research is to extend these preliminary findings in a more thorough investigation of the seasonal changes in leaf chlorogenic acid concentration in relation to active oxygen scavenging activity in natural populations of *Mahonia repens.* Such a comprehensive analysis will greatly improve our understanding of the role and action of phenolic compounds in biochemical adaptation to environmental stress.

9700559 Isoprene Emission From Oak Leaves: Testing the Hypothesis of Thermal Protection and Interactions With Drought
Monson, R.K. **Grant 97-35100-4418**

University of Colorado
Department of Environmental, Population, and Organismic Biology **$110,000**
Boulder, CO 80309 **2 Years**

Isoprene is a volatile, five-carbon compound produced by the leaves of many plant species, with the greatest amounts being produced by forest trees in the oak and poplar genera. Once emitted to the atmosphere, isoprene reacts with oxidative chemicals to produce tropospheric ozone, a potent pollutant with the capacity to damage crop productivity and human health. Thus, considerable research has been conducted to determine which environmental and physiological factors control the rate of isoprene emission from forest trees. One aspect of isoprene emission that has been overlooked in past research is the nature of its possible benefits to the plants. In other words, why do plants emit isoprene? A recent hypothesis that has been put forth states that isoprene, which is produced in the chloroplast, protects leaves from high-temperature damage during summer heat spells. If this is correct, isoprene emission may represent a previously overlooked protective mechanism contributing to thermal protection of forest productivity. In this project, the hypothesis of thermal protection will be assessed using chlorophyll fluorescence to monitor heat damage in oak trees growing in an oak-hickory forest in Tennessee. Oak trees are strong isoprene emitters. Measurements will be made at different times during the season and on plots with different levels of water stress to determine if thermal protection by isoprene is enhanced during the warmest parts of the year and during drought (which reduces the capacity for leaves to cool themselves through evaporative processes). The measurements will focus on whether the hypothesis is supported using plants growing in their natural environment, and, if it is supported, what the mechanisms might be that promote isoprene-induced thermal tolerance.

9700708 Integrating the Various Stress Responses of *ADH* by *In Vivo* Footprinting
Ferl, R.J.; Paul, A. L. **Grant 97-35100-4457**

University of Florida
Horticultural Sciences Department **$110,700**
Gainesville, FL 32611-0690 **2 Years**

The reaction of plants to environmental stresses can include changes at many morphological, cellular and biochemical levels, but the regulation of gene expression is a very important and fundamental aspect of the stress response. An essential part of regulated gene expression is the binding and interaction of specific regulatory proteins called transcription factors. The binding of these factors constitutes the essential act of gene regulation. In the past several years a considerable amount of information in the field of gene regulation has offered insight into the structure, function and regulation of the nuclear protein factors that regulate gene activity. We have developed a novel means for mapping the binding of transcription factors. The process is called *in vivo* footprinting. The overall goal of this proposal is to gain insight into the relationships among the protein-DNA interactions that regulate alcohol dehydrogenase (*Adh*) gene activity in response to various stresses. The main question is, "When the *Adh* genes are activated in response to different stresses, are the same transcription factor interactions used or do the different activating stresses utilize a different array of factors?" Thus, the first step is *in vivo* footprinting of cells induced by the various stresses. This step will answer the basic question of whether the same factors are used by each stress. The second step is the *in vivo* footprint analysis of mutations that influence *Adh* expression. This step will address the functional contribution of the footprinted elements and the coordinate or independent nature of the interactions with the elements.

9700561 Role of Ethylene Synthesis and Perception in the Acquisition of Abscission Competence
Lashbrook, C.C. **Grant 97-35100-4192**

University of Florida **Postdoctoral Fellowship**
Horticultural Sciences Department **$90,000**
Gainesville, FL 32611-0690 **2 Years**

Abscission is the process by which plants shed organs such as leaves, flowers and fruits. Organ detachment takes place within a layer of specialized cells called an abscission zone. Both developmental and environmental signals can activate plant organ abscission. Cotton, an important cash crop in the United States, is especially sensitive to environmental abscission signals. Significant shedding of cotton buds, flowers, young bolls and leaves can be triggered by variations in ambient temperature, water availability, nutritional status and insect pressure. Ethylene, a plant hormone, plays a critical role in promoting and coordinating abscission responses. Significant changes in ethylene synthesis and perception have been measured in detaching organs. The objective of this research is to elucidate the molecular mechanisms that regulate ethylene synthesis and perception in response to common abscission cues. Ethylene synthesis is dependent upon the enzymes ACC synthase and ACC oxidase. Enzymically produced ethylene is recognized by hormone receptors, called ETRs (Ethylene Response proteins), triggering a chain of events culminating in abscission. Genes encoding ACC synthase, ACC oxidase and ETR receptors will be cloned from ethylene-treated cotton abscission zones. The role of these genes in conferring abscission competence will be assessed in two experimental systems. Cotton leaves abscissing due to natural aging will serve as a model for developmentally-induced abscission. Cotton buds shed in response to water stress will serve as a model for environmentally-regulated abscission. An understanding of mechanisms conferring abscission competence in plants may ultimately suggest strategies to reduce premature abscission in agriculturally important crops.

9700704 Adapting Plants to Excess Light by Bioengineering Violaxanthin De-epoxidase Activity
Yamamoto, H.Y. **Grant 97-35100-4851**

University of Hawaii, Manoa
Department of Plant Molecular Physiology **$168,800**
Honolulu, HI 92822 **3 Years**

Plants have limited capacity to use light for photosynthesis. Thus, full sunlight exceeds photosynthetic capacity about two- to four-fold for "sunplants" and as much as ten-fold for "shade plants." Light in excess of photosynthetic capacity is potentially damaging and must be dissipated safely as heat. The dissipation mechanism, however, must be closely regulated so that energy otherwise needed for plant growth and development is not discarded. Recent evidence suggests that special carotenoid pigments that are present in all higher plants take part in energy dissipation. These pigments comprise a complex biochemical system commonly known as the violaxanthin or xanthophyll cycle. The operation of this cycle helps regulate energy flow to photosynthesis or, if in excess, to heat. A key element of the cycle is the enzyme, violaxanthin de-epoxidase (vde). We recently cloned the gene for vde. This accomplishment offers new opportunities for understanding the mechanism of energy dissipation and, potentially, to modify the adaptation of plants to excess light by genetic engineering. We will genetically engineer *Arabidopsis thaliana*, to enhance or suppress vde levels, and characterize the effects of these alterations on energy dissipation, growth and development. It is hypothesized that the adaptive range and productivity of plants can be increased by transforming plants with vde.

9700534 Control of Glutathione Biosynthesis and Its Role in Plant Protection
Oliver, D.J.; Xiang, C. **Grant 97-35100-4503**

Iowa State University
Department of Botany **$110,700**
Ames, IA 50011-1020 **2 Years**

A broad range of environmental stresses decrease plant growth and crop yield. Plants are protected from many of these environmental factors by the endogenous chemical, glutathione. These stresses include oxidative (chilling) damage, heavy metals, xenobiotic chemicals (mainly herbicides), and air pollutants such as ozone and sulfur dioxide. We have cloned the genes for glutathione biosynthesis and will be using these genes in a range of biochemical and molecular biology experiments designed to explore the biosynthesis of this key metabolite. Our research has two overall directions. We are producing plants (using the model organism *Arabidopsis*) with increased and decreased capacity for producing glutathione. This will be accomplished by constructing transgenic plants where the genes for glutathione synthesis are over-expressed and also plants containing antisense copies of those genes. Those plants with low glutathione levels will allow us to test the role of this chemical in protecting plants from stress and those plants with elevated levels will show if we can increase the resistance to stress. In addition, we are interested in determining how plants respond to stress by activating the genes for glutathione biosynthesis. We will accomplish this by measuring mRNA levels and by producing transgenic plants containing promoter-reporter gene fusions. We will use heavy metals (specifically cadmium and copper) as a model for stress in these plants because they are biochemically well-characterized.

9700703 The Signal Transduction Pathway for Response to Altered CO_2
Spalding, M.H. **Grant 97-35100-4210**

Iowa State University
Department of Botany **$110,700**
Ames, IA 50011-1020 **2 Years**

The long term objective of the proposed research is to understand the pathway in plants that leads to changes in gene expression in response to a change in carbon dioxide (CO_2) availability. Because of increasing atmospheric CO_2 and its potential impact on growth and productivity of plants, the importance of understanding plant responses to changing CO_2 has become critical. Although many plants respond to increased CO_2 with decreased expression of photosynthesis-associated genes, both the perception of altered CO_2 and the pathway converting that "signal" to a response are difficult to study. This is because the changing CO_2 concentration is perceived *via* metabolic changes and generates complex responses in the plant. Thus, acclimation of the single-celled alga *Chlamydomonas* to CO_2 concentration changes was chosen as a simpler model system for study of CO_2 regulated gene expression. *Chlamydomonas* exhibits a variety of responses to changing CO_2, including specific changes in gene expression. We will investigate the response pathway for adaptation of *Chlamydomonas* to changes in CO_2 by using the product, periplasmic carbonic anhydrase (PCA), of one of the limiting-CO_2 induced genes as a reporter for action of the response pathway. *Chlamydomonas* mutants unable to respond to CO_2 changes, identified as lacking expression of the reporter gene, will be generated and used to identify components of the response pathway. The information gained from this simple model system should help us to understand and to lay the foundation for further investigations of the responses of more complex plants to increasing CO_2 concentrations, including the potential for modification of the response in crop plants.

9700603 Stress Response of Glycolytic Genes in *Arabidopsis*

Shih, M.C. **Grant 97-35100-4213**

University of Iowa
Department of Biological Sciences **$110,700**
Iowa City, IA 52242-1297 **2 Years**

Most crop plants, including barley, maize, sorghum, and wheat, can only tolerate very transient flooding. In contrast, rice plants can survive much longer under flooding conditions. Understanding of the molecular mechanisms of how plants respond to oxygen deprivation is essential toward improving flood tolerance of these important crop plants. We have been studying the effects of anoxia (no oxygen) and hypoxia (low oxygen) on the expression of GapC and ADH genes that encode cytosolic glyceraldehyde-3-phosphate dehydrogenase (GAPDH) and alcohol dehydrogenase in *Arabidopsis thaliana.* We found that both GapC and ADH genes can be induced by anoxic or hypoxic treatment. Our results also indicate that multiple signaling events occur during the course of anoxia and hypoxia. We have obtained mutants in which the expression of the ADH gene was not induced by anaerobic conditions. In the time period covered by this project, we intend to perform the following experiments: First, temporal patterns of cellular and morphological responses during hypoxia and anoxia will be established. Second, genetic and molecular analyses will be used to determine what signal molecules are responsible for triggering various responses. By combining genetic, molecular, and biochemical approaches, the proposed research should contribute to the understanding of molecular mechanisms of plant defense against environmental stresses, and the effects of environmental signals on gene expression in eukaryotic organisms.

9700879 Translational Control of Gene Expression in Desiccation Tolerant Vegetative Plant Tissue

Wood, A.J. **Grant 97-35100-4476**

Southern Illinois University **New Investigator Award**
Department of Plant Biology **$105,000**
Carbondale, IL 62901-6509 **2 Years**

The vast majority of higher plants, including most important food crops, are susceptible to drought and incapable of withstanding desiccation. In order to gain a full understanding of stress-inducible processes in plants, it is often beneficial to develop simple model plants for study. Model plants that exhibit stress tolerant traits are useful tools in elucidating the molecular processes involved in tolerance and may provide unique genetic material that can impact breeding programs for improved crop stress management.

Tortula ruralis is a desiccation-tolerant bryophyte and has the potential to become an important model system for the study of posttranscriptional gene control in response to severe water deficit. In response to rehydration, desiccated *T. ruralis* produces a set of peptides unique to the rehydrative state utilizing a desiccation-stable mRNA pool. The changes in gene expression *in vivo* due to drying and rehydration are primarily mediated at the translational level; translational control mechanisms provide a sensitive and flexible response to environmental stresses. These data suggest that one mechanism for the observed mRNA stability and posttranscriptional gene control is the interaction of a *trans*-protein factor with specific mRNAs. The RNA gel mobility shift assay will be used to assess this possibility. Our proposed research will further characterize the unique posttranscriptional gene expression of *T. ruralis* by identifying and characterizing the RNA-binding protein(s) and investigating the nature of the mRNA-protein interaction.

9700602 Function and Regulation of Metallothionein Genes in *Arabidopsis thaliana*

Goldsbrough, P.B. **Grant 97-35100-4593**

Purdue University
Department of Horticulture **$168,800**
West Lafayette, IN 47907-1165 **3 Years**

Plants require a number of metals for normal growth and metabolism. However, these essential metals are toxic to plants when taken up in excessive amounts. Plants must therefore balance availability of metals while preventing toxicity. One protective mechanism used by plants is binding metals to ligands, thereby preventing metals from participating in more damaging reactions. Metallothioneins are low molecular weight, cysteine rich proteins that bind metals. Genes encoding these proteins have been cloned from several plants and a family of eight metallothionein genes has been characterized in *Arabidopsis*. Analysis of this gene family will serve as a model to understand the function and regulation of these genes in plants. The hypothesis being tested is that plant metallothionein genes are involved in normal metabolism of essential metals such as copper and zinc, and also play a role in protecting plants from metal toxicity. Plants with reduced expression of specific metallothionein genes will be produced by a variety of strategies and analyzed for growth in the presence of sub- and supra-optimal concentrations of copper, zinc, cadmium and other metals. Tissues that express metallothionein genes, under normal growth conditions and in response to metals, will be determined. Interactions between metallothioneins and another class of metal ligands, phytochelatins, will be examined using an *Arabidopsis* mutant which does not make phytochelatins. Metallothionein gene structure will be examined in a metal hyperaccumulator, *Thlaspi caerulescens*, which, like *Arabidopsis*, is a member of the Brassicaceae. These experiments will provide insight into the function of metallothioneins in plants.

9700558 Salt Tolerance of Plants Expressing the Ca^{2+} Dependent Protein Phosphatase Calcineurin
Hasegawa, P.M.; Pardo J.M.; Bressan, R.A. **Grant 97-35100-4655**

Purdue University
Department of Horticulture **$110,700**
West Lafayette, IN 47907-1165 **2 Years**

Salt stress is one of the most significant constraints to agricultural productivity and can be particularly acute when crops are irrigated. Salt tolerance has been a recalcitrant trait to transfer into crop plants by traditional plant breeding methods. Consequently, the goal of this project is to improve salt stress tolerance of plants through biotechnology. Expression of activated yeast calcineurin in transgenic tobacco plants substantially enhanced salt stress survival. Calcineurin is a Ca^{2+}-/calmodulin-dependent protein phosphatase that, in yeast, facilitates salt adaptation through the regulation of processes that facilitate intracellular ion relations. Current hypothesis envisages calcineurin as a key regulatory intermediate, hence the modulation of this molecule exerts control over numerous mechanisms that must function in concert to elicit salt adaptation. The research objective of this project is to define the physiological functions by which calcineurin mediates salt tolerance of plants. Primary emphasis will be experiments that identify the mechanisms that are regulated by calcineurin to re-establish Cl^- and maintain Na^+, K^+, Ca^{2+}, and Cl^- homeostasis in salt stress environments. This information will provide insight into the signal transduction pathway that regulates salt adaptation in plants and will lead to the identification of genes that function coordinately to mediate salt tolerance. These genes, along with calcineurin, will be a resource for improving salt tolerance of crops using biotechnology.

9700700 Functional Characterization of Higher Plant Phosphate Transporters
Raghothama, K.G. **Grant 97-35100-4211**

Purdue University
Department of Horticulture **$168,800**
West Lafayette, IN 47907-1165 **3 Years**

Phosphorus is one of the major macronutrients required by plants. Phosphate transporters associated with the plant membrane mediate uptake of phosphorus from soil. Recent cloning of phosphate transporters in our laboratory has opened new avenues to study the molecular and biophysical aspects of phosphate transport mechanisms in plants. The long term goal of our research is to understand the fundamental role of the phosphate transporters in plant growth and development, and to genetically engineer agronomically important crops to enhance their efficiency in acquiring phosphorus from soil. We propose to characterize the biophysical and biochemical nature of plant phosphate transporters using *Xenopus* oocytes and membrane vesicles. The membrane localization of transporters will be accomplished by immunological studies. The biological function of transporters will be determined in transgenic plants expressing the transporter genes. Results from the proposed studies will provide fundamental information about function, cellular localization and regulation of a major nutrient transporter in plants. A better understanding of regulation of phosphate transporter gene(s) expression and uptake mechanisms will aid in developing strategies to genetically engineer efficient phosphate uptake in plants. A judicious application of fertilizers in combination with plants that are more efficient in nutrient uptake should help farmers maintain high crop productivity while reducing the production cost and the impact of production on the environment.

9700754 Drought Stress and Abscisic Acid Induced Gene Expression in Plants
Ho, T.H.D. **Grant 97-35100-4228**

Washington University
Department of Biology **$168,000**
Saint Louis, MO 63130-4899 **3 Years**

The long term objective of my research is to investigate the regulation of expression and function of plant genes which are induced by drought stress and a phytohormone, abscisic acid (ABA). Two drought/ABA induced barley genes have been studied by my laboratory: *HVA1*, encoding a protein enriched in maturing seeds and *HVA22*, encoding a potential regulatory protein which is also found in several other organisms, including yeast, several plant species, and humans. In the previous USDA supported project, my laboratory identified the smallest regulatory unit which is essential for the ABA/stress induction of these genes. This regulatory unit, termed ABA Response Complex (ABRC), consists of two separate stretches of DNA. Regarding the function of these genes, it has been observed that overexpression of *HVA1* in transgenic plants confers a higher level of resistance to drought and salinity stress. The specific goals for the current project are 1) to study the proteins which interact with the regulatory unit, ABRC, in order to understand the molecular mechanisms underlying stress/ABA induction of gene expression, and 2) to investigate the role of *HVA1* gene in the establishment of stress resistance following a biochemical approach to analyze how the protein encoded by this gene interacts with other cellular components. It is hoped that new insights revealed in this project could be used in the future to improve plant responses to stressful conditions.

9700549 Aluminum Resistant Mutants in *Arabidopsis*
Howell, S.H.; Kochian, L.V. **Grant 97-35100-5050**

Boyce Thompson Institute for Plant Research
Plant Molecular Biology **$168,000**
Ithaca, NY 14853-1801 **3 Years**

Aluminum (A1) toxicity is the major problem in the growth of crop plants in acid soils in the United States and throughout the world. This is a project to examine the molecular mechanisms of A1 toxicity and resistance and to identify genes that confer A1 resistance. *Arabidopsis* has been chosen as a model plant for this study because its sensitivity to Al is similar to crop plants and because one can isolate genes in *Arabidopsis* for which mutations have been identified. A collection of Al resistant (alr) mutants in *Arabidopsis* has been developed and genetically characterized. The alr mutants have the common characteristic that they are more able to prevent the uptake of A1 into their root tips. Our work will focus on a mutant called alr-128 which releases from its root tips higher levels of several organic acids including the Al-chelating organic acid, malate. The specific aims of this proposal are to: 1) clone and sequence the Al resistance gene represented in alr-128 using transposon tagging or map-based cloning techniques, 2) study the expression, regulation and function of the cloned genes, and 3) investigate the physiological and biochemical basis for Al resistance in the alr mutants. To study organic acid release in alr-128, the role of plasma membrane anion channels and intracellular compartmentalization of organic acids will be analyzed.

9700540 Integrated Genetic and Physiological Investigations of Aluminum Tolerance Complexity in Crops
Kochian, L.V. **Grant 97-35100-4501**

USDA Agricultural Research Service
U.S. Plant, Soil, and Nutrition Laboratory **$168,800**
Ithaca, NY 14853 **3 Years**

Acidic soils limit crop productivity on a significant portion of agricultural lands in the United States and elsewhere in the world. A major reason for this is that aluminum solubilized from the soil by soil acidity is toxic to plant roots. Some cultivars of different crops are more tolerant of aluminum than others and thus are capable of growing better in acidic soils. Unfortunately, there is relatively little understanding of the physiological basis of aluminum tolerance in such cultivars or its genetic basis. The research to be undertaken with this funding entails: 1) an examination of the diversity of aluminum tolerance in a set of different grain crops, both at the genetic level and the mechanistic level; 2) the identification of chromosome locations of aluminum tolerance genes in these species; 3) the integration of these two types of information in order to assign a mechanistic basis to different aluminum tolerance genetic loci; and 4) the comparison of such information from different grain crops to determine if aluminum tolerance gene location and function is conserved across species. Ultimately, an understanding of the diversity of aluminum tolerance mechanisms in grain crops, coupled with knowledge of the chromosome locations of the genes that encode them, will permit the efficient development of aluminum tolerant crop cultivars with one or more tolerance mechanisms. Furthermore, knowledge of the chromosome locations of aluminum tolerance genes will be a fundamental requirement for future efforts to clone aluminum tolerance genes in these crops.

9701228 Signal Transduction Pathways Controlling Plant Growth Adaptations to Water Deficit
Conley, T.R. **Grant 97-35100-4227**

Oklahoma City University **New Investigator/Strengthening Award**
Department of Biology **$110,700**
Oklahoma City, OK 73106-1493 **2 Years**

When a corn seedling lacks sufficient water for normal growth, elongation of the shoot decreases or stops altogether. In contrast, the root system of the seedling continues to grow, presumably as a means of finding water and bringing it to the plant. The regulatory mechanism that controls plant growth adjustments to water stress is unknown. In responding to other environmental cues, such as light and temperature stress, plants utilize signaling pathways that are similar to those used by yeast and animals. It is likely that plants use similar processes to control their responses to water stress One important class of molecules that participates in virtually all signaling pathways is that of the protein kinases. The focus of this project is the isolation of a protein kinase that is rapidly activated by water stress in the roots of corn seedlings. This protein kinase is found in the roots before the onset of water stress and is activated in the region of the root where growth occurs. Preliminary work has shown that this molecule may function as a switch at an early step in controlling the growth adjustments of water-stressed corn seedlings. Isolating this protein may be an important step towards understanding how plants control their responses to drought and may facilitate progress towards genetic manipulation of plants with improved drought tolerance.

9700533 Root Architecture and Phosphorus Acquisition Efficiency: An Interdisciplinary Approach
Lynch, J.P.; Brown, K.M. **Grant 97-35100-4456**

Pennsylvania State University
Department of Horticulture **$110,700**
University Park, PA 16802-4200 **2 Years**

Low phosphorus availability limits plant growth over much of the earth's land surface. The efficiency of phosphorus acquisition by plants is therefore of great scientific and humanitarian concern. We propose to address this problem by generating novel data, tools, methods and concepts for the understanding and improvement of phosphorus acquisition by plant roots. Root growth is important in efficient phosphorus acquisition, but this topic is poorly understood because of difficulties in analyzing root architecture. Our overall goal is to understand the architectural features of roots that regulate the efficiency of soil phosphorus acquisition. We will do this by comparison of bean (*Phaseolus vulgaris*) genotypes with contrasting root traits and contrasting adaptation to low phosphorus soils through quantitative measurement of the carbon 'costs' and phosphorus 'benefit' resulting from distinct traits, combined with hypothesis testing in an explicit computer simulation of bean root growth, and application of theoretical mathematics to the quantification and interpretation of root form. By contributing to the development of fertilizer-efficient crops, this research would enhance the competitiveness and long-term viability of American agriculture and would enhance the environment and natural resource base upon which a sustainable agricultural economy depends. Fertilizer-efficient crops could be grown at less cost to the farmer and with less environmental impact from fertilizer runoff and leaching. This research will also generate new analytical tools and quantitative concepts needed to understand fundamental aspects of root systems and would, therefore, assist research on other soil stresses important in U.S. agriculture.

9700948 Protective Role of Chloroplastic Ascorbate Peroxidase in Transgenic Plants
Allen, R.D.; Webb, R.P. **Grant 97-35100-4673**

Departments of Biological Sciences and Plant and Soil Sciences
Texas Tech University **$105,000**
Lubbock, TX 79409-3131 **2 Years**

Hydrogen peroxide and other toxic reactive oxygen intermediates are produced as by-products of the highly energetic photochemical reactions in plant chloroplasts. Exposure of plants to environmental stresses such as drought or extreme temperatures increases the production of these damaging molecules. Efficient removal of reactive oxygen intermediates is critical since even low concentrations can damage chloroplast components and inhibit photosynthesis. Ascorbate peroxidase is the critical hydrogen peroxide-scavenging enzyme in chloroplasts. In previous work, we have shown that expression of elevated levels of ascorbate peroxidase in transgenic plants leads to significant increases in tolerance to oxidative damage caused by stress treatment. In this project, we will extend these findings by producing and testing additional transgenic plants that express genes for the ascorbate peroxidase isoenzymes that are native to chloroplasts. In addition, we will produce transgenic plants that contain combinations of ascorbate peroxidase genes and genes for another antioxidant enzyme, superoxide dismutase. We anticipate that the enhanced expression of both ascorbate peroxidase and superoxide dismutase could have synergistic effects that may result in more substantial increases in plant stress tolerance. If this is the case, development of future transgenic crop plants that incorporate these genes could potentially lead to varieties that are better able to withstand environmental stresses, resulting in increased productivity and decreased risk.

9700593 Response of Canopy Photosynthesis to Turbulence-Induced Light Fluctuations
Hipps, L.E.; Bugbee, B. **Grant 97-35100-4502**

Utah State University **Strengthening Award**
Plants, Soils, and Biometeorology **$110,700**
Logan, UT 84322-4820 **2 Years**

Accurate models of CO_2 exchange in plant communities are essential for both agricultural concerns and for quantifying the role of vegetation in the carbon balance of the planet. The response of photosynthesis to light has been well studied. However, nearly all such studies have only considered steady-state or unchanging light conditions. In reality, turbulence causes rapid and complex fluctuations of light in plant canopies, often termed as sunflecks. Recent studies on individual leaves suggest that transient changes in light result in photosynthetic rates which differ from those under steady-state light values. Such investigations have never been conducted at the scale of a plant canopy. In addition, the present models for photosynthesis generally cannot and do not consider any effects of fluctuating light on CO_2 exchange. This study will integrate concepts and measurements from micrometeorology and plant physiology to measure the response of canopy photosynthesis to wind-induced light fluctuations. The CO_2 flux into the plant canopy will be measured and combined with measurements of the light regime inside the canopy. This will allow direct examination of the response of photosynthesis to the changing light conditions. In addition, a state of the art canopy model called CUPID will be run to simulate the CO_2 exchange for steady-state light conditions. Integrating the measurements with the model simulations will demonstrate whether fluctuations of light alter the photosynthetic rates, which would be predicted by current approaches.

9700563 Effect of Enhanced UV-B Radiation on Carbon Dynamics in Selected Tree Species
Bassman, J.H.; Edwards, G.E.; Robberecht, R. **Grant 97-35100-4215**

Washington State University
Department of Natural Resource Sciences **$110,700**
Pullman, WA 99164-6410 **2 Years**

Loss of stratospheric ozone is resulting in increased levels of solar ultraviolet radiation reaching the earth's surface. The potentially deleterious effects of enhanced UV-B radiation on agronomic crops has been well documented. However, our understanding of the effects of increased levels of UV-B on trees remains rudimentary. This project examines the consequences of long-term enhanced UV-B radiation on economically and ecologically important tree species. Trees, because of their long life spans, are subject to the accumulated effects of stresses in ways which annual plants are not. Thus, future development and productivity of forests may be substantially altered. Our studies will focus on primary plant responses that include leaf growth and development, photosynthesis, the efficacy of protective processes against UV-B-induced damage, and whole-plant productivity. This study will extend knowledge of UV-B effects on plants and should lead to a better understanding of mechanisms by which tree species respond to long-term UV-B exposure and, thus, how forests may respond to such global climate change. The results may also help us select or breed for plant characteristics that increase resistance to UV-B radiation injury.

9701067 Genetic Mechanisms of Chilling Tolerance
Tokuhisa, J.G. **Grant 97-35100-4200**

Washington State University
Institute of Biological Chemistry **$110,700**
Pullman, WA 99164-6340 **2 Years**

Crop damage by low temperatures accounts for monetary losses in the United States second only to drought and flooding losses. Most crops of tropical origins such as soybean, rice, maize and cotton are easily damaged by low temperatures whereas crops of temperate origins are relatively immune to low temperatures. The long-term goal of this research is to understand how plants of temperate origins resist the damaging effects of chilling. This understanding can be used to develop crop varieties that are better protected against low temperature damage. To achieve this goal, I have isolated specific mutants from *Arabidopsis thaliana*, a plant that grows normally at chilling temperatures. These mutants appear normal at regular growth temperatures. However, at chilling temperatures they show injuries such as inhibited or restricted growth, yellowing leaves or high pigment content. This low-temperature-dependent behavior tells us that these mutants lack capabilities that are not required at normal temperatures, but are required when the plant is grown at low temperatures. I am identifying the mutated genes and determining how these genes contribute to chilling resistance. The specific research is on a gene demonstrated to have a role in the development of chloroplasts at chilling temperatures. This gene has been isolated previously and shown to encode a ribosomal RNA methylase. The research results are new because they define a function for this gene product and are the first example of this gene in plants. The proposed research will determine how this ribosomal RNA methylase contributes to chilling resistance.

FOREST/RANGE/CROP/AQUATIC ECOSYSTEMS

Panel Manager - Dr. R. Kelman Wieder, Villanova University
Program Director - Dr. Timothy Strickland

The Ecosystems Program is designed to increase our understanding of interactions between abiotic and biotic components of ecosystems. This basic information is essential to assess environmental conditions and the sustainability of agriculture within an ecosystem context. Research on the structure, function and sustainability of forest, rangeland, crop, or aquatic (including riparian, wetland and estuarine areas, but not oceanic) ecosystems is supported. Results provide better information and tools for agricultural planning, evaluating the effects of agricultural practices on environmental quality and sustainability, and characterizing the functional integrity of natural ecosystems.

9701033 Role of Spatial Pattern on Plant Community Productivity, Stability and Invasibility
Laca, E.A.; Rice, K.J. **Grant 97-35101-4356**

University of California, Davis
Department of Agronomy and Range Science **$200,000**
Davis, CA 95616-8515 **3 Years**

We will study the spatial distribution of plant species as a management tool to improve productivity, sustainability, and conservation of range and pasture systems. Our objectives are: to measure the effects of spatial distribution of plants and disturbances on the stability, productivity, and invasibility of plant communities; to determine if these effects are explained by seed dispersal and competition processes; and to determine the effects of plant patch size on the grazing pattern of livestock. We will test whether productivity, stability and invasibility of plant communities are inversely related to size of disturbance patches by clipping and applying herbicides on plots in the annual rangeland. The response of plant community stability, productivity and resistance to invasion by weedy species will be studied as a function of the size of monospecific patches in seeded pastures where selective and random defoliation treatments will be applied. The effect of plant patch size on livestock's ability to graze selectively will be determined in the annual rangeland by using a novel technique with which the precise location of bites will be recorded. Results of this research will allow better prediction of ecosystem change in response to changes in grazing pressure and to the regime of abiotic disturbances such as drought and frosts, and will suggest seeding patterns to control the longevity and stability of seeded pastures and revegetated areas. A better understanding of spatially-explicit plant competition and plant-animal interactions will also improve our ability to assess rangeland and pasture ecosystem sustainability and susceptibility to global change.

9700794 Recovery of Rangeland and Abandoned Croplands Following Removal of N Stress
Redente, E.F.; Paschke, M.W.; Klein, D.A. **Grant 97-35101-4317**

Colorado State University
Department of Rangeland Ecosystem Science **$265,000**
Fort Collins, CO 80523-1478 **3 Years**

Millions of acres of arid and semiarid rangeland in the western United States have been subjected to cultivation during the past 140 years. Many of these farms have been abandoned due to environmental, economic, or social factors. Often, these abandoned fields are taken-over by exotic weedy plants with little or no value to livestock or wildlife. Even those that are seeded to desirable plant species can take decades or longer to regain usefulness. Our past research on such sites has demonstrated that soil nitrogen (N) availability is an important factor controlling the recovery of the plant community. Microbially-mediated N cycling appears to exert a strong influence on plant community changes during the process of recovery. By manipulating levels of soil N we have shown that we can speed up or slow down the process of recovery. This is a very encouraging finding. However, before we can use this knowledge we need to understand the long-term implications of this new approach.

Our project will address this concern by examining the response of plant and soil communities following removal of N treatments. Our studies will determine if N availability can be manipulated in a practical way that may provide a management practice for accelerating the economic and biological recovery of disturbed lands. A better understanding of the mechanistic role of N in ecosystem recovery will be important, not only for the management of areas in need of restoration, but also for understanding the possible consequences of N inputs associated with fossil fuel combustion.

9705828 Is Productivity of Old Forests Limited by Tree Hydraulic Conductance?
Ryan, M.G. **Grant 97-35101-4376**

USDA Forest Service
Rocky Mountain Experiment Station **$57,670**
Fort Collins, CO 80526-2098 **3 Years**

As trees age, their growth rate slows, and they never grow beyond a certain, predictable height. The maximum height is correlated with growth rates when trees are young. Foresters use this information, in the form of growth and yield tables, to manage forests. Despite the widespread use of growth and yield tables, nobody knows WHY the maximum height of trees is so predictable or WHY productivity declines in old forests. In previous studies, we found that the productivity of old pine trees is limited by their ability to move water from the soil to foliage. The sheer size of old trees, along with other changes of "old age", increases the resistance to water movement. With a reduced supply of water, old trees support less photosynthesis, and therefore grow more slowly. We call this the "hydraulic limitation" hypothesis. We believe the hydraulic limitation hypothesis provides a universal explanation for maximum height of trees and reduced productivity in old forests. In this project, we will determine whether hydraulic limitation occurs in diverse ecosystems. We will do intensive research at three sites, and we will analyze foliage samples many other locations to see if there is a specific change in chemistry that is consistent with the hypothesis. Understanding the mechanisms that ultimately limit forest height growth should allow new insights for maintaining the production and sustainability of commercial forests. It should also help foresters predict changes in forest development that occur when site conditions change.

9700565 Overstory Structure and Regeneration Precesses in Longleaf Pine Ecosystems
Mitchell, R.J.; Palik, B.J.; Jones, R.H.; Mou, P. **Grant 97-35101-4419**

Joseph W. Jones Ecological Research Center
Ichauway, Inc. **$445,000**
Newton, GA 31770-9640 **2 ½ Years**

Developing strategies for timber production while maintaining and/or enhancing ecological values is an important contemporary challenge for forest management. Retaining a portion of the mature trees in a stand after harvesting has proven to be crucial to maintaining characteristics of natural forests and sustaining native plants and animals. Although no such work has been done in longleaf pine systems, silvicultural research of this type is likely to yield important findings. Longleaf pine forests are important economically and ecologically to the southeastern United States. Loss of longleaf pine forests and the critical habitat they provide is of ever increasing interest. One reason for the loss of longleaf pine is the relative difficulty in regenerating forests after harvest. Presently most silvicultural systems used to regenerate longleaf pine are even-aged (i.e. the mature wood is removed and seedlings established following removal). However, the diverse forests that European settlers described were all aged (i.e., longleaf seedlings were found within larger gaps among mature trees). We will investigate how opening size and the arrangement of overstory trees retained on site influence the growth and survival of longleaf seedlings. Understanding these mechanisms will allow landowners who have longleaf pine forests greater options for forest management that is directed to producing income from timber harvests, while simultaneously enhancing the ecological amenities that can be derived from these forests.

970882 Suspended Sediment and Pesticide Interaction and Toxicity to Larval Fish
Summerfelt, R. **Grant 97-35101-4339**

Iowa State University
Department of Animal Ecology **$90,000**
Ames, IA 50011-3221 **2 Years**

Agricultural runoff has been alleged to be the principle cause for degrading water quality and for loss of biodiversity of aquatic life in streams. Eroded soil represents three times the volume of material contributed by the next leading source to streams and rivers. Although it has been assumed that sediment, suspended sediment or pesticides (herbicides and organophosphorus insecticides, OPs) from water erosion are the major problem for streams in agricultural watersheds, little work has been done to distinguish among the three. Because some pesticides strongly absorb to colloidal clays from eroded soil, they are thought to be biologically unavailable. The question that has yet to be considered in risk assessment is whether pesticides that are adsorbed to colloids may be desorbed and transferred to fish when the suspended colloids come in contact with gill tissue, a metabolically active epithelium. Therefore, we propose laboratory and field experiments to partition sediment effects *per se* from sediment-pesticide interactions as factors affecting survival of larval fishes.

9700672 Forest Ecosystem Response to the Introduced Hemlock Woolly Adelgid in Southern New England
Foster, D.R.; Orwig, D.A. **Grant 97-35101-4316**

Harvard University
Harvard Forest **$240,000**
Petersham, MA 01366 **3 Years**

In the northeastern U.S., pathogen and pest outbreaks have impacted forests through geological time and with increasing regularity in the past century. Hemlock woolly adelgid (HWA) (*Adelges tsugae*), an introduced aphid-like insect from Asia, is rapidly expanding through the range of eastern hemlock (*Tsuga canadensis*) and has the potential to severely reduce or eliminate this important late-successional species. HWA infestation consequently offers the potential of examining an important evolutionary and historical process - the spread and disturbance impact of an exotic pest. As part of a study investigating stand to landscape forest dynamics resulting from HWA infestation, we will examine initial community and ecosystem response of twenty hemlock stands in south-central Connecticut in collaboration with J. Aber and J. Jenkins at the University of New Hampshire. Our major objectives are to assess mortality patterns in hemlock, evaluate subsequent changes in stand environment and composition, and relate these to patterns of regeneration, community reorganization, and ecosystem processes. At the landscape level we will map and characterize the spatial distribution of hemlock prior to HWA infestation in a 5900 km^2 transect that extends through Connecticut. A time-series of geographic information system overlays will be compared to evaluate the temporal and spatial patterns of damage generated by HWA since the time of its arrival. This project is the first quantitative analysis of the abundance of hemlock and HWA impact in southern New England, and it will enable us to assess the landscape-level, biological, edaphic, and historical factors that control the spread of mortality and stress in hemlock.

9700775 Alternative Landscape Management: Hypothesis, Options, and Returns
Chen, J.; Desanker, P. **Grant 97-35101-4315**

Michigan Technological University **New Investigator Award**
School of Forestry and Wood Products **$220,000**
Houghton, MI 49931 **3 Years**

Different harvesting methods result in different structural patterns across the landscape. Size and placement of patches, corridors, and other features of the landscape are determined in part by the harvesting method implemented on an area. Landscape level effects of stand level management activities are becoming increasingly recognized as important. However, little information currently exists on the effects of these resultant large scale patterns on such critical issues as biodiversity. Therefore, managers have limited understanding of how their actions influence biodiversity and economic returns at broader scales. We propose to test the hypothesis that landscape structure (i.e., the spatial arrangement of patches, corridors, ecotones, and matrix) directly controls the distribution and diversity of plant species, wildlife habitat quality, and economic output. We will collect field data in a carefully delineated landscape in northern Wisconsin and attempt to develop predictive models between these variables and landscape structure, which will vary as a result of different silvicultural alternatives. These predictive relationships will then be employed in a stand projection model (Forest Vegetation Simulator, FVS) and a harvest allocation model (HARVEST). Feedback based on predictions of ecological and economic values will be used to modify current management alternatives and/or develop other creative plans for the landscape. A workshop for managers and scientists will allow evaluation of landscape designs before and after application of the models. Results can be used directly by land managers in revising current management guidelines to sustain economic returns while maintaining diversity and habitat quality for both public and private landowners.

9700732 Nitrogen Controls Over Tree Root Production
Friend, A.L.; Coleman, M.D. **Grant 97-35101-4338**

Mississippi State University **Strengthening Award**
Department of Forestry **$200,000**
Mississippi State, MS 39762-9681 **3 Years**

Fine roots are tremendously important to forest productivity and ecosystem health. Despite their small size (< 2 mm dia.), they consume a large fraction of biomass production, enable trees to acquire nutrients for growth, and absorb from the soil nutrients that might otherwise pollute water. Root growth is known to increase in response to soil nitrogen (N) in small patches (fertilizer bands, pockets of organic matter, etc.). Yet, paradoxically, root production has been reported to decrease with N added to a forest stand. We will attempt to resolve this conflict by testing the hypothesis that increasing plant N concentration (after fertilization) decreases the responsiveness of fine roots to small patches of soil N. Eastern cottonwood (*Populus deltoides*) was chosen as the model system for this project due to its ecological importance, rapid growth rate, and applicability of results to commercial forestry, agroforestry, and bioremediation. Greenhouse studies will test the hypothesis using split-root experiments, with detailed information collected on response dynamics and changes in tissue chemistry. Field studies will test the hypothesis by establishing a large cottonwood plantation, installing plots treated with a range of complete fertilizer amendments, and patch N-enrichments within plots. Video imaging of roots and soil core analysis will be used to quantify root responses. Rigorous experimental control and measurements of tree biomass and N accumulation will make the field study particularly useful. Future studies may use this information to improve nutritional management of short-rotation forestry, to explore its ramifications to ecological processes, and/or to explain the phenomena at a more mechanistic physiological level.

9700735 Quantifying an Ecosystem Perturbation: Forests, Mycorrhizae, and Red-Backed Voles
Mills, L.S. **Grant 97-35101-4355**

University of Montana **New Investigator/Strengthening Award**
Wildlife Biology Program **$120,000**
Missoula, MT 59812 **2 Years**

Forest ecosystems have received special attention in the Pacific Northwest since President Clinton convened a special scientific panel to evaluate how management will affect forests and wildlife. One of the most crucial biotic components of Northwest forest ecosystems involves the dynamics of red-backed voles, which are a primary dispersal vector for the fruiting bodies of mycorrhizal fungi (truffles). Mycorrhizae are, in turn, essential for tree regeneration following harvest. Previous work has shown that California red-backed voles are infrequent near edges of forest remnants and absent from the clearcuts surrounding remnants in SW Oregon, but positively associated with truffles and decaying logs within the remnants. At the same time, truffles are lacking from clearcuts, most likely to be found under logs, and infrequent on the edges of forest remnants. The proposed work will fill in two gaps critical to forest sustainability. First, I will evaluate whether the striking demonstrations of negative edge effects and isolation for red-backed voles in 1990/1991 still hold nearly a decade later. Second, I will use large, replicated trapping grids to assess whether the observed negative edge effects translate into decreased birth and survival rates for red-backed voles in forest interiors relative to those on the edge, implying a demographic “sink.” Such information will not only provide insight into demographic feedback between forest system perturbation and the persistence of red-backed voles, but it will also help establish protocols for long-term monitoring a species that is pivotal in Northwest forest ecosystems.

9700772 Plant Species Invasions in Freshwater Wetlands: Ecosystem-Level Effects
Yavitt, J.B. **Grant 97-35101-4321**

Cornell University
Department of Natural Resources **$250,000**
Ithaca, NY 14853-3001 **3 Years**

Research will examine the effects of invader plant species on ecosystem-level properties and processes in peat-forming wetlands in central New York state. Similar wetlands occur throughout the northeast Atlantic and northern tier states, extending as far west as North Dakota, South Dakota and Iowa, and provide food and habitat for wildlife and waterfowl. These wetlands are under heavy assault by exotic plants such as purple loosestrife and common reed that establish mono-specific stands and reduce or eliminate feeding areas, nesting sites, and migration areas for fauna in native stands of sedges, rushes and cattails. Previous research has considered species interactions, loss of biodiversity, and biocontrol, but there are no comprehensive studies addressing how invasions affect (i) net primary production, (ii) organic matter decomposition, (iii) the production (and consumption) of atmospheric trace gases, (iv) nutrient cycling, and (v) water balance in the ecosystem. The present study uses species removal/species transplant studies designed to determine ecosystem-level responses to invader plant species. Species invasions may not affect net primary production above ground, but should affect processes below ground including increased rates of plant root production, organic matter decomposition and, in particular, increased emission of atmospheric greenhouse gases (methane, carbon dioxide) to the atmosphere. It is also suspected that nutrient cycling rates will increase following plant species invasions. The results will help managers predict short-term versus lasting effects of plant species invasions on valuable, yet, diminishing wetland resources.

9700784 Effects of Agricultural Land-Use on Native Fish in the Willamette Basin
Bayley, P.B.; Bolte, J. **Grant 97-35101-4319**

Oregon State University
Department of Fisheries and Wildlife **$205,000**
Corvallis, OR 97331 **3 Years**

The project goals are to determine most likely causal mechanisms for the persistence and abundance of indigenous fish species in the agricultural landscape of the Willamette Valley, and to identify existing agricultural practices most likely to ensure the persistence of those species. Project objectives are (1) develop a conceptual framework for relating native fish occurrences and abundances to agricultural and other potential environmental effects, (2) compile existing data sources on quantitative fish samples in a common format appropriate for analysis, (3) compile major land-use types (agriculture, urban, forest), agricultural classification groups (based on fertilizer use, pesticide use, water use, annual benefit/cost criteria), and riparian areas in geographic information system format based on existing data sources, (4) compile other information relevant to native fish persistence, including exotic fish abundances, hydrological features, water quality, and instream structural habitat, (5) perform exploratory and statistical analyses based on hypotheses resulting from the conceptual framework, (6) assemble results in the form of a predictive model, (7) evaluate the model and use results to design and obtain additional samples, and (8) repeat objectives 5, and 6 to produce a definitive predictive model. The preliminary conceptual framework combines potential explanatory factors in a spatial hierarchy. Emphasis will be placed on ascertaining and quantifying the effects of agricultural classification groups. However, inclusion of other variables, some indirectly related to land-use, may be necessary to provide robust predictions and provide conditions in which agricultural practices that ensure native fish survival can be recommended.

9700919 SOM and N Dynamics in an Old-Growth Douglas-fir Ecosystem
Sollins, P. **Grant 97-35101-4256**

Oregon State University
Department of Forest Science **$275,000**
Corvallis, OR 97331-7501 **3 Years**

A better understanding of what controls nutrient availability in forests is needed to predict forest productivity, exchange of CO_2 with the atmosphere, and nutrient loss to groundwater. Our project sets up long-term plots in which rates of plant organic inputs to the soil and forest floor are altered. Plots, located at the Andrews Experimental Forest, Oregon, in old-growth Douglas-fir forest, are patterned after similar plots already established in two eastern U.S. forests and at a grassland site. Unlike the existing plots, the Oregon site is strongly nitrogen limited and organic matter inputs are dominated by wood rather than foliage and fine roots. As research progresses we will use newly developed techniques to measure changes in the composition of the organic compounds in the soil and in the availability of those compounds to be decomposed by microbes with concurrent release of nitrogen for uptake by plants.

9700796 Is Productivity of Old Forests Limited by Tree Hydraulic Conductance?
Yoder, B.J.; Ryan, M.G.; Williams, M.; Rastetter, E.B. **Grant 97-35101-4318**

Oregon State University
Forest Science Department **$438,998**
Corvallis, OR 97331-7501 **3 Years**

As trees age, their growth rate slows, and they never grow beyond a certain, predictable height. The maximum height is correlated with growth rates when trees are young. Foresters use this information, in the form of growth and yield tables, to manage forests. Despite the widespread use of growth and yield tables, nobody knows WHY the maximum height of trees is so predictable or WHY productivity declines in old forests. In previous studies, we found that the productivity of old pine trees is limited by their ability to move water from the soil to foliage. The sheer size of old trees, along with other changes of "old age", increases the resistance to water movement. With a reduced supply of water, old trees support less photosynthesis, and therefore grow more slowly. We call this the "hydraulic limitation" hypothesis. We believe the hydraulic limitation hypothesis provides a universal explanation for maximum height of trees and reduced productivity in old forests. In this project, we will determine whether hydraulic limitation occurs in diverse ecosystems. We will do intensive research at three sites, and we will analyze foliage samples many other locations to see if there is a specific change in chemistry that is consistent with the hypothesis. Understanding the mechanisms that ultimately limit forest height growth should allow new insights for maintaining the production and sustainability of commercial forests. It should also help foresters predict changes in forest development that occur when site conditions change.

9700872 A Field-Scale Study of Carbon, Water and Energy Flow in Irrigated Rice
Heilman, J.L.; McInnes, K.J.; Wilson, L.T.; Baker, J.T. **Grant 97-35101-4320**

Texas A&M University
Department of Soil and Crop Sciences **$260,000**
College Station, TX 77843 **3 Years**

Rice is the most important food crop and largest irrigated crop in the world. In the U.S., rice production is a $9 billion dollar industry and is especially important to the economy of the southern U.S. and California. The sustainability of rice production is important in the U.S., since much of the rice is grown in regions where there are not alternative crops. The major threats to the U.S. rice industry are high costs of production, due in large part to increasing competition for and increasing costs of irrigation water, and foreign competition. An understanding of the mechanisms by which plant-environment interactions effect plant growth, grain yield and water use is key to improving productivity and sustainability. Thus, the overall objective of this three-year study is to determine how and why productivity and water use of irrigated rice are controlled by atmospheric and soil environments. Plant-environment interactions will be investigated in a commercial field by combining continuous measurements of carbon dioxide uptake at the field scale with detailed measurements of photosynthesis, energy exchange and water use. These measurements, along with computer simulation, will be used to develop a better understanding of the underlying processes by which productivity and water use are effected by the environment.

9700721 Watershed Scale Variability of Inorganic Nitrogen Dynamics in the Southern Appalachians

Van Miegroet, H.; Nicholas, N.S.; McCarthy, L.E.; Creed, I.F. **Grant 97-35101-3244**

Utah State University **Strengthening Award**
Department of Forest Resources **$291,000**
Logan, UT 84322-5215 **3 Years**

The high-elevation red spruce-Fraser fir forests in the Southern Appalachians leak large amounts of nitrate from the soil. This is thought to be the result of high nitrogen inputs from atmospheric pollution combined with a low capacity of the ecosystem to retain nitrogen. Such low nitrogen retention leads to high nitrate levels in the stream water which in turn deteriorate water quality. The high-elevation forests are quite heterogeneous with numerous gaps and large variations in stand age, the number of live and dead standing trees, and the amount of dead wood on the surface. Little is know about how important such spatial variability is to nitrogen retention in different parts of the watershed and ultimately to the overall nitrogen export from the catchment. This study will examine spatial differences in the release/retention of nitrogen within a 17.4-ha catchment located in the high-elevation spruce-fir forest of the Great Smoky Mountains National Park, its relationship to spatial patterns in forest structure and the distribution of dead wood, and its impact on streamwater nitrate levels. We hypothesize that the differences in N input with elevation, in local forest structure, and in abundance and relative decay of dead wood causes significant but predictable variation in nitrogen release from soils across the watershed, with some areas acting as stronger nitrogen source areas than others. We will test this hypothesis through a combination of geographic information system and model-based watershed characterization, actual field measurement of nitrogen status of 50 plots located throughout a small watershed, and modeled vs. measured nitrate export from the watershed.

9700769 Accelerated Soil Weathering due to Nutrient Inputs in Wisconsin Cropping Systems

Barak, P.; Laird, D.A.; Posner, J.L. **Grant 97-35101-4313**

University of Wisconsin, Madison
Department of Soil Science **$147,700**
Madison, WI 53706-1299 **3 Years**

Agricultural systems in the U.S. have been using particularly large acid-forming nitrogen inputs as part of production practices for 50 years. Reports of soil acidification, including base depletion, due to N inputs are widespread. Furthermore, reports from Kentucky, Kansas, Wisconsin, and Saskatchewan based on long-term fertility trials show reduction of one of the fundamental soil properties, the effective cation exchange capacity (CEC) of soils, variously measured over the course of 5 to 40 years, as a result of acidification. Records of aglime use nationwide show that controlled use of base materials has not kept pace with acid-forming nutrient inputs. Plants interact with soil acidification processes by generating alkalinity as part of the assimilative process for N and S. Some of the plant-generated alkalinity is stored in the shoot as organic anions and may either be harvested as part of the cropping practice or returned to the soil as residue. Since the concentration and location of organic anions is dependent upon the species, the plant part, the nutritional status of the plants, and environmental factors, the proper location for study of this plant/soil interaction is in the field. Since the effect of a single year's crop on soil acidity and soil weathering is likely small, it is proposed that the problem be studied at the system level using the Wisconsin integrated cropping systems trial. Six different cropping systems--cash grain and dairy/forage at three different levels of input--will be studied for their long-term effects on soil acidification and soil weathering.

9700770 Coupling Agroecosystem Geographic Information Systems with Neural Network Models

Hart, G.L. **Grant 97-35101-4373**

University of Wisconsin, Madison **Postdoctoral Fellowship**
Department of Soil Science **$81,330**
Madison, WI 53706-1299 **2 Years**

Artificial neural networks (ANN) have been used in a wide variety of applications including neuroscience , electronics, robotics, process control, image and voice recognition, and financial analysis. Artificial neural networks have also been utilized as tools to enhance conventional statistical techniques. Geographic information systems (GIS) such as ARC/INFO are utilized extensively in digitizing, managing, and displaying spatial data on landscape scales. Because of the complex, multivariate factors which interact to affect agroecosystems and the extensive landscapes over which these systems are managed, it has become a common theme recently to couple GIS with computer simulations to address certain production, economic, and environmental issues. However, no one has designed or employed a technique to analyze these data to address questions concerning agricultural productivity, sustainability or resource management issues at the scale of agroecosystems. Directly extrapolating experimental plot data to landscape scale has serious limitations. A primary reason for this limitation is that cause and effect relationships can not be easily deduced from small-scale experiments (research plots) conducted on segments of agroecosystems, making interpretation and application of experimental results difficult or impossible. This project will investigate the possibility of using ANN models to assess a range of interrelated components of agroecosystems. Coupling a GIS database with a trained neural network model could advance our understanding of interactions and aid in management of complex agricultural systems.

9700671 Investigating the Variable Response of Forest Watersheds to Chronic N Deposition

Peterjohn, W.T.; Cumming, J.R. **Grant 97-35101-4794**

West Virginia University
Department of Biology
Morgantown, WV 26506-6057

Strengthening Award
$217,000
3 Years

Chronic additions of nitrogen by acid deposition may eventually exceed the capacity of a forest to utilize this nutrient - a condition known as nitrogen saturation. Once this capacity is exceeded, the excess nitrogen may degrade water quality, reduce soil fertility, alter the release of greenhouse gases, and contribute to forest decline. Several studies have noted, however, that not all forests receiving elevated inputs of atmospheric nitrogen show symptoms of nitrogen saturation. The factors responsible for the variable response of forests to high nitrogen inputs are currently unknown and are the focus of this study. In this project, we will compare two forested watersheds that are similar in their age, climate, geology, land-use history, and nitrogen deposition regime. Yet, despite their similarities, the concentration of inorganic nitrogen in stream water leaving these watersheds differs by a factor of two. To identify factors that are associated with the different behavior of these watersheds, we will measure a variety of soil, microbial, and plant variables that may account for their different abilities to retain inorganic nitrogen. Results from this study will test our current understanding of nitrogen saturation, expand the existing long-term data set for these watersheds, and will help us identify characteristics that make some forests more resistant to nitrogen saturation.

SOILS AND SOIL BIOLOGY

Panel Manager - Dr. Ronald F. Turco, Purdue University
Program Director - Dr. Timothy Strickland

The Soils and Soil Biology Program supports research that will further our understanding of the basic mechanisms contributing to the immense diversity in soil chemical, physical and biological characteristics in both managed and unmanaged soils and sediments. The program was developed in recognition that soils provide the interface between the biotic and abiotic components of terrestrial ecosystems. It is in the soil that many of the essentials for the production of biomass are obtained and here that nutrients from dead biomass are recycled into usable forms.

9700760 Molecular Simulation of Adsorption at the Clay Mineral/Solution Interface

Miller, D.M.; Teppen, B.J.; Schafer, L. — **Grant 97-35107-4362**

University of Arkansas, Fayetteville
Department of Agronomy — **$233,000**
Fayetteville, AR 72701 — **2 Years**

The mobility and bioavailability of chemicals such as herbicides in soils are controlled largely by their interactions with phyllosilicate clay minerals and humus. The interaction that is of primary interest in this regard is adsorption, the accumulation of a substance at an interface between two phases. Given its obvious importance in the maintenance of environmental quality, it is imperative that we understand how adsorption reactions occur at the molecular level. We are investigating adsorption using the techniques of computational chemistry. Specifically, we are using commercially available molecular dynamics (MD) software to simulate the basic molecular mechanisms of adsorption at the clay mineral/aqueous solution interface. Using the results of quantum mechanical calculations and what experimental data is available, we have derived a force field (a set of potential energy functions and parameters) which can be used in conjunction with this software to accurately predict the geometries and vibrational motions of the clay minerals gibbsite, kaolinite, pyrophyllite and beidellite. A first-generation set of force field parameters for clays such as montmorillonite and vermiculite that contain octahedrally coordinated magnesium has also been derived and will allow us to simulate the surface chemical behavior of these important soil clay minerals. With the force fields that we have derived, we intend to model such phenomena as the thermodynamics of cation exchange reactions at clay mineral surfaces, clay mineral swelling as a function of water content and ionic potential of the exchangeable ions, and the interactions of both pristine and chemically modified clay surfaces with organics.

9701031 Selenium Biogeochemistry in a Semi-Arid Ecosystem: Mass Balances under Field Conditions

Frankenberger, W.T.; Jury, J.; Jury, W.A. — **Grant 97-35107-4853**

University of California, Riverside — **Strengthening Award**
Department of Soil and Environmental Sciences — **$230,000**
Riverside, CA 92521-0001 — **2 Years**

Selenium (Se) is a widespread contaminant throughout the western U.S. due to its occurrence in sediments and saline drainage water. It is toxic to mammals and birds at the high concentrations which are found in evaporation ponds, where Se is concentrated. Remediation of seleniferous soils and sediments is of extreme importance to the sustainability of U.S. agriculture for the next decade. Natural remediation might occur to a certain extent due to microbial activity, evolving methylated Se from soil (mainly dimethylselenide). However, biomethylation can be enhanced by (i) the amendment of specific organic C sources (e.g., pectin, zein, casein); and (ii) cultivation of specific vegetation stimulating microbial activity via root exudates and also volatilizing Se following uptake. A combination of these processes can be used as an effective bioremediation technology. Very little information is available on the influence of vegetation and the rhizosphere on the biomethylation of Se. Generally, Se volatilization has been investigated in small laboratory systems under artificial and non-varying conditions. Field studies need to be conducted to reflect realistic conditions, including antagonistic processes (e.g., leaching, adsorption, and elemental precipitation).

Experiments will be conducted with a novel constructed wind tunnel, set up in the field above a lysimeter. A complete balance sheet under realistic outdoor conditions will be obtained. Se volatilization will be continuously monitored using activated charcoal traps. Simultaneously, Se movement in soil, its occurrence in leachate and uptake by vegetation as well as its biochemical conversion via microbial transformations will be investigated. The experimental plan includes the influence of different vegetation, soil amendments and climatic conditions on the biomethylation of Se in the soil/plant system. All experimental data will be analyzed with a four compartment modeling approach (insoluble, soluble, volatilized and leached Se).

This project will address mass balances of Se subject to volatilization, leaching, adsorption, elemental precipitation and plant uptake. Information gained from this study will be useful in establishing *in situ* bioremediation technology for soils contaminated with Se.

9700852 Assessment and Emission Reduction of Methyl Bromide Alternative Fumigants
Gan, J.; Yates, S.R.; Becker, J.O.; Jury, W.A. **Grant 97-35107-4378**

University of California, Riverside **Strengthening Award**
Department of Soil and Environmental Sciences **$205,000**
Riverside, CA 92521-0001 **3 Years**

Soilborne plant pathogens and parasitic nematodes can cause extensive damage to many crops, especially in intensive agriculture. Over the last few decades, soil disinfestation has relied on the use of chemical disinfectants, primarily fumigants. Due to their high vapor pressures, most of these compounds have inflicted negative effects on the environment or human beings. Recently, emissions of methyl bromide were implicated in stratospheric ozone depletion, and its use is scheduled for phase out in the US by 2001. Our lack of knowledge of the mechanisms underlying the environmental behavior of these volatile pesticides, and employment of application methods of high emission potentials, have clearly contributed to the many failures in the use of fumigants in modern agriculture. Since few non-chemical methods are available at this time, preserving the use of the few remaining fumigants by minimizing their negative environmental effects is of immediate importance.

The two most important alternatives to methyl bromide are 1,3-dichloropropene and methyl isothiocyanate, both classified as Clean Air Act substances, and both frequently detected in the air under current application practices. We propose to conduct laboratory, field and simulation studies to understand the variables that control fumigant transport and volatilization, and through manipulating these variables, develop feasible application-soil management protocols that will have adequate efficacy, but will allow significantly less emissions. Our research approach is multidisciplinary collaboration among soil physicists, chemists and plant scientists. The integration of environmental studies with evaluation of biological efficacy will assure applicability of the research results to real life scenarios.

9701028 Response of Biogeochemical Controls and Stable Isotopic Composition of N_2O to Land Usage Change in the Colorado Shortgrass Steppe
Mandernack, K.W; Mosier, A.; Wahlen, M. **Grant 97-35107-4412**

Colorado School of Mines
Department of Chemistry and Geochemistry **$190,000**
Golden, CO 80401 **3 Years**

Nitrous oxide (N_2O) is an atmospheric trace gas which is important in global warming and stratospheric ozone destruction and whose concentration is rising at an unaccountable rate of 0.25%/year. Uncertainties in the source terms for N_2O partly explain this rise in addition to the large discrepancy between currently known sources and sinks for the global budgets. Emissions of N_2O from fertilized cropland soils are believed to be a major reason for the increased accumulation rate within the atmosphere. Better identification of the natural and anthropogenic sources, as well as microbial processes that influence emissions from cropland soils, is essential before the N_2O budget can be balanced. The biological processes believed to be most important in N_2O production are nitrification and denitrification. Anthropogenic disturbances that affect the microbial populations and dynamics of nitrogen turnover in soils may also affect the global N_2O budget. Addition of N fertilizers to soils, increased tillage, and pasturization can affect microbial nitrogen cycling in soils and result in increases in N_2O production and emission to the atmosphere. Such changes in land use thus affects greenhouse gas exchange. From field and laboratory studies, this project will investigate the environmental and microbial processes important for N_2O formation in both agricultural and native grassland soils of Colorado at the United States Department of Agriculture/Agricultural Research Service Central Plains Experimental Range. This study will ultimately help better constrain the magnitude of the global N_2O sources and sinks.

9701008 Earthworms and Soil Processes in California Grassland Ecosystems
Hendrix, P.F. **Grant 97-35107-4410**

University of Georgia
Institute of Ecology **$120,000**
Athens, GA 30602-2202 **3 Years**

The stability and sustained productivity of grassland ecosystems are largely dependent upon the release of nutrients held within plant residues and soil organic matter. Several studies have suggested that microbial activity, which mediates the release of these nutrients, is strongly influenced by soil invertebrates. Earthworms, in particular, may be critical components in grassland ecosystems because they are the principal agents for 1) the fragmentation and incorporation of plant residues into the soil, where they are more available for microbial attack, and 2) the modification of soil structure, which has an impact on the spatial distribution of soil microorganisms. This project will investigate the influence of earthworms on microbial activity and nutrient dynamics in grassland ecosystems in California. The research will be conducted in two phases over a three-year period. Phase I will address basic questions of population and feeding ecology of native and exotic earthworms in northern California grasslands. The objectives are to 1) identify environmental influences on species assemblages in grazed and ungrazed grasslands, and 2) delineate food sources, feeding strategies, and potential competitive interactions among the species. Phase 2 will consist of laboratory and field enclosure experiments with the objectives of 1) further defining earthworm feeding strategies and 2) measuring relative influences of native and exotic earthworms on C and N dynamics and plant growth. Together, these studies will increase our understanding of basic ecology of earthworms, as well as their potential importance in the management of grassland productivity.

9701000 Spatial Dynamics of Soil and Rhizosphere Bacterial Populations: Effects on Plasmid Transfer Events
Knudsen, G.R.; Dandurand, L.M. **Grant 97-35107-4377**

University of Idaho
Department of Plant, Soil, and Entomological Sciences **$80,000**
Moscow, ID 83844-2339 **2 Years**

There is increasing interest in the release of genetically engineered microbes (GEMs), into soil and on plant roots, for beneficial purposes including bioremediation of toxic compounds and biological control of plant pathogens. However, potential impacts and risks of released GEMs, including ecological effects or transfer of recombinant (engineered) genes, are difficult to predict. This impedes productive utilization of recombinant bacteria in potentially beneficial applications. Commonly, bacteria can exchange gene sequences by means of extra-chromosomal DNA in the form of plasmids. This project will quantitatively investigate and model the spatial and temporal structures of introduced and resident bacterial populations in soil and on roots, specifically as they influence the transfer of recombinant gene sequences, on plasmids, between bacterial species. Organisms used will include well-characterized bacteria used for biocontrol and bioremediation, as well as native soil and root-inhabiting bacteria. As a framework for these investigations, a computer simulation model will be used, which allows microbial populations (and their effects) in a large number of individual microsites to be modeled. The model will be tested experimentally in soil and root systems, and spatial statistics (geostatistics) will be used to evaluate and refine the model's predictions.

9700962 Gaps in the Biogeochemical Sulfur Cycle: Pathways for the Evolution of CS_2 and COS from Soil
Morra, M.; Fendorf, S. **Grant 97-35107-4411**

University of Idaho
Soil Science Division **$145,000**
Moscow, ID 83844-2339 **2 Years**

Sulfur is an essential element for life because of its incorporation into biomolecules composing living organisms. Maintenance of sufficiency levels for plants and animals involves a complex biogeochemical cycle in which sulfur is converted among various organic and inorganic forms. The soil environment is a primary component in the biogeochemical sulfur cycle, mediating these changes and acting as a source and sink for various sulfur compounds. Gaseous sulfur evolution from soil is a major input to the atmospheric sulfur pool. These gaseous losses from soil reduce the amount of sulfur potentially available for plants, thus enhancing sulfur limitations observed for crop species. Correspondingly, atmospheric deposition of sulfur compounds contributes to soil and surface water acidification and the potential acceleration of nutrient leaching in soils. Although field evolution has been well documented, virtually nothing is known concerning the pathways for formation of two key sulfur gases, COS and CS_2. We will perform a series of studies with soils collected from a variety of U.S. locations to determine potential pathways which can be used to explain soil emissions of these two sulfur gases. Novel methods of analyses requiring the use of various types of instrumentation will be developed. We expect at project termination to delineate a pathway for COS and CS_2 emissions from soil, filling a gap in our current understanding of sulfur biogeochemistry. The proposed research has significant practical implications with respect to maintaining a sustainable agricultural system, enhancing crop productivity, and protecting environmental quality.

9700973 Root and Soil Carbon Contributions to the Stability and Function of Soil Aggregates
Smucker, A.J.M.; Paul, E.A.; Snider, R.M. **Grant 97-35107-4322**

Michigan State University
Crop and Soil Sciences **$330,815**
East Lansing, MI 48824-1325 **2 Years**

Soil structure controls soil porosity which influences the flow of water and associated soil ions, plant root growth, and numerous microbial and mesofaunal activities. This research identifies feed-back abiotic and biotic mechanisms which contribute to the formation, function, and stability of soil aggregates during frequent soil wetting and drying cycles associated with most agricultural soils. Spatial patterns of carbon (C) from plant and soil organic matter (SOM) sources will be identified at the surfaces and within soil aggregates. Cementation of soil aggregates by C from plants or transported by small soil animals, fungi and other microbes will be identified by contrasting separate sources of natural isotopes of C. The accumulations of less-negative delta ^{13}C signals from corn roots, within soil aggregates, will be compared to accumulations of mor-negative delta ^{13}C signals generated by native SOM. Radio-carbon dating will be used to characterize old resistant pools of SOM. Localized accumulations of C with soil aggregates will be assessed by mechanically peeling aggregates into concentric layers by using a newly developed wind-tunnel soil aggregate erosion machine. Soil C sources will be identified by mass spectroscopy. Strategically localized C and associated microorganisms within soil aggregates control the stability of different sized aggregates. Knowledge of these ecosystem processes at the soil aggregate level will identify critical components essential for improving belowground detrital foodweb models and for identifying soil components and mechanisms which improve their resistance to breakage during tillage and other operations associated with sustainable agricultural production.

9700929 Coupled Processes: 2,4-D Sorption, Transport, Degradation and Microbial Selection
Inskeep, W.P.;McDermott, T.R.;Wraith, J.M. **Grant 97-35107-4361**

Montana State University
Department of Plant, Soil and Environmental Sciences **$257,000**
Bozeman, MT 59717-3120 **3 Years**

Microbial degradation is one of the major processes responsible for the dissipation of agricultural pesticides. The degradation of pesticides by soil microorganisms is also one of the most difficult processes to predict in fate and transport models, due to the variable and complex nature of factors controlling pesticide bioavailability and microbial activity. Further, the chemical and physical properties of a soil define the microenvironments in which soil microorganisms respond to inputs of agricultural pesticides. This project will focus on the effects of the soil physical-chemical environment on (i) the degradation kinetics of 2,4-D, and (ii) the microbial selection and diversity of 2,4-D degrading microorganisms. Both soils and model enrichment environments will be used to test effects of sorption and transport processes on rates of 2,4-D degradation and on the corresponding community structure of 2,4-D degrading microorganisms. Results from this project will be used to improve our understanding of (i) the effects of sorption and transport on pesticide degradation rates in soils, (ii) modeling approaches for predicting coupled processes (degradation and transport) in soils, and (iii) the chemical and physical factors which may control microbial selection and microbial community structure of pesticide degrading microorganisms.

9700974 A Seasonal Study of Diversity and Abundance of Nitrifying Bacterial Populations
Gsell, T.C. **Grant 97-35107-5064**

University of Montana **Postdoctoral Fellowship**
Division of Biological Sciences **$88,413**
Missoula, MT 59812-1002 **2 Years**

Nitrification is a subprocess of the nitrogen cycle whose critical steps are mediated by bacteria. Nitrification is particularly important in agro-economic systems because it facilitates mobilization of nitrogen added as fertilizer, affecting both uptake by plants and loss from the system. Nitrifying bacteria are notoriously difficult to study using standard culture-based methodologies. Molecular techniques have facilitated progress in the study of specific nitrifier populations, but emphasis on nitrification and nitrifiers in the context of the total bacterial community has been lacking. The objective of this study is to determine and compare the diversity and abundance of nitrifiers from disparate environments. This study will focus on the hypothesis that in areas of high ammonia-N abundance (e.g. in traditional agricultural management) a lower diversity of nitrifiers exists, with primarily ammonia-insensitive types being dominant. Conversely, in areas of low ammonia-N concentration, a greater diversity of ammonia-sensitive nitrifiers will prevail. This hypothesis will be tested through a comparative analysis of agricultural soils, prairie soil, forest soil, river water and sediments, an oligotrophic lake, a hyper-eutrophic lake, marine water and sediment, and estuarine waters and sediments. The main objective of this research is to determine whether the nitrifying community from agricultural sites is distinct from non-agricultural nitrifier profiles in a cross-season comparison. For each sample, ammonia-N concentrations will be determined. The relative abundance of ammonia-sensitive and -insensitive, nitrifier populations will be determined. Total bacterial community DNA purified directly from each sample will be analyzed using molecular techniques which will generate diversity indices for populations participating in nitrification across sites and through seasons.

9701081 Abiotic Transformation of Agrochemicals in Wetland Soil and Sediments
Chin, Y.; Traina, S.J.; Roberts, A.L. **Grant 97-35107-4358**

Ohio State University
Department of Geological Sciences **$265,000**
Columbus, OH 43210 **3 Years**

Wetlands are highly efficient at "filtering" out pesticides adsorbed to sediment particles. Although this serves a valuable role in purifying surface waters, contaminants thereby become concentrated in the sediment phase, potentially increasing the exposure of sensitive organisms to agrochemicals. One possibility that has not been adequately examined by prior research is that the anoxic (i.e., oxygen depleted) conditions that develop in wetlands could promote the formation of naturally occurring substances (iron and sulfur in their "reduced" forms, and natural organic matter) in wetlands sediments that can react chemically with certain pesticides. Moreover, little is known about the types and properties of the chemicals formed from these reactions. This project will attempt to determine 1) how quickly these reactions occur, 2) the identity and amounts of products that are formed, and 3) the pathways by which these reactions proceed. The results of these investigations will provide information useful in assessing the environmental fate of agrochemicals in wetland sediments; will facilitate desighn of agrochemical waste treatment systems based on constructed wetlands; and will assist in predicting the environmental significance of agrochemical transformation products.

971010 Compartmentalization and Coupling of Nitrogen Cycling in Soil
Myrold, D.D.; Bottomley, P.J. **Grant 97-35107-4357**

Oregon State University
Department of Crop and Soil Science **$268,000**
Corvallis, OR 97331 **2 Years**

Cycling of nitrogen in soils is important for plant production and impacts environmental problems at local to global scales. Most previous work has studied nitrogen cycling at spatial scales much larger than those of the microorganisms that process nitrogen in soil. We think it is likely that there are important interactions among microorganisms and between microorganisms and their local environment that have a strong influence on how nitrogen is processed in soil. Therefore, we will study the cycling of nitrogen at the microbial scale in three important soil habitats: soil crumbs, soil associated with plant roots (known as the rhizosphere), and fragments of decaying plant tissues. We anticipate that nitrogen cycling processes, such as the production and consumption of ammonium and of nitrate, will be strongly influenced by these three habitats. Our work will utilize a stable isotope of nitrogen, nitrogen-15, to specifically determine the rates of ammonium and nitrate production and consumption. The results of this study will tell us how important microhabitats, such as soil crumbs and the rhizosphere, are in determining the overall nitrogen cycling characteristics of soils. The major benefit will be enhanced understanding of the soil nitrogen cycle and will provide information for future studies on the relationships between different soil microbial populations and communities on their function. We may also gain practical insights that will allow us to manage soils to maximize nitrogen availability to plants while minimizing negative environmental consequences.

9701021 Evolution of Variable-Charge Soil Properties Along a Chronosequence in Hawaii
Chorover, J. **Grant 97-35107-4360**

Pennsylvania State University
Department of Agronomy **$200,000**
University Park, PA 16802-3504 **3 Years**

Surface charge properties regulate nutrient bioavailability, mineral weathering and colloid transport processes in soils. When soils develop from volcanic debris in humid tropical environments, high water fluxes generate a mineralogical progression from volcanic glasses and other rapidly weathered primary minerals through metastable secondary phases and finally to kaolin group clay minerals and hydroxides of aluminum and iron. These soils, which possess variable-charge throughout pedogenesis, support high and rapidly growing human populations whose livelihoods depend on the soil resource. The present research addresses the rate of development of particle surface properties (surface charge, ion adsorption, dissolution behavior) as a function of soil and mineral development in a well-characterized chronosequence (0.3 to 4,100 ky) of volcanic debris soils. Project objectives are to measure the changes in variable-charge characteristics of chronosequence soils as a function of weathering age; to determine the effects of solution chemistry and surface charge on soil dissolution behavior; and to identify the rapidly dissolving solid phases that give rise to the elemental composition of soil solution. Quantitative wet-chemical methods and spectroscopic techniques will be combined to track the relationship between variable-charge properties and dissolution behavior through the course of soil development.

9701053 Towards a Better Understanding of Root Lifespan: Root Proliferation and Root Herbivory
Eissenstat, D.M.; Yanai, R.D. **Grant 97-35107-4359**

Pennsylvania State University, University Park
Department of Horticulture **$365,000**
University Park, PA 16803-4200 **3 Years**

Root lifespan has important consequences for plant growth and productivity, nutrient cycling and the global carbon cycle. Roots, like other plant organs, have a life history: they are born, age and die. Growth of a root system, the ability of a root system to relocate in nutrient-rich patches, and the eventual architecture of a root system are largely determined by the birth and death of its parts. A successful theory of root population dynamics would explain the variation in lifespan as a function of environmental conditions, such as temperature, moisture and soil fertility. Such a theory is in its infancy, at best. A cost-benefit model of root longevity predicts that a root will be shed when its carbon costs outweigh its nutritional benefits, i.e., when lifetime root efficiency (defined as benefit/cost) is maximized. One problem with this theory is that no one has measured root respiration and nutrient uptake of field roots as a function of root age. These data are critical to testing this model. We propose to determine age-specific rates of root respiration, uptake of nitrate and phosphate, and putative defense compounds of apple roots. Another problem with this theory is that roots eaten by herbivores may die before their efficiency is maximized. We will examine the relative importance of root herbivory and parasitism on root longevity in fertile and infertile patches using selective pesticides in an apple orchard. These experiments will lead to a better prediction of the factors affecting root lifespan.

9700959 Regulation of Carbon Transport and Metabolism in VA Mycorrhizal Symbiosis
Pfeffer, P.E.; Douds, D.D.; Nagahashi, G. **Grant 97-35107-4375**

USDA Agricultural Research Service
Eastern Regional Research Center **$175,000**
Wyndmoor, PA 19038-8598 **2½ Years**

High productivity agriculture exacts a high cost in terms of energy and our environment. A less costly and nondestructive means for achieving the same goal rests on the establishment of a viable low-input farming system. However, to implement such a plan we must develop plant systems that can efficiently scavenge and utilize soil nutrients at low levels. Fungi known as vesicular arbuscular mycorrhizal (VAM) fungi colonize, or invade plant root cells, establishing a symbiotic (mutualistic) relationship. In this association, these fungi hasten plant growth, and improve stress resistance by increasing the root mass to facilitate the transport of needed nutrients to the plant cells. Ideally one would want to produce these fungi in pure culture as an inoculum or “biofertilizer” for field application. However, since mycorrhizal fungi are obligate symbionts (require the presence of a plant root for development) they normally cannot grow and complete their life cycle unless root tissue is present. To efficiently produce large quantities of pure inoculum we must understand what factors are provided by the plant in this symbiosis. In this study we propose to examine a number of critical factors of the symbiosis including 1) effects and nature of recognition and signaling between the plant and fungus, 2) the identification of the exchanged plant/microbe nutrients, 3) the determination of the active metabolic pathways for those nutrients in the fungus in symbiotic and free living states. Having this information we hope to induce the fungus to complete its life cycle and proliferate in pure culture.

9700814 Post-tillage Soil Structure and Pore Space Dynamics
Or, D.; Snyder, V. **Grant 97-35107-4899**

Utah State University **Strengthening Award**
Department of Plants, Soils, and Biometeorology **$100,000**
Logan, UT 84322-4820 **2 Years**

The tilled "plow layer" of agricultural soils plays a crucial role in determining crop productivity and the transport of gas, water and chemical fluxes in the environment. A characteristic of this layer is the periodic disruption of soil structure by tillage followed by gradual resettling of the soil into more stable state. Two processes are considered fundamental: (i) fracture and breakdown of primary clods produced by tillage due to wetting and drying cycles; and (ii) subsequent rejoining of loose soil fragments into an increasingly cohesive soil mass of reduced porosity. The processes in turn determine temporal changes in transport properties through their effects on evolution of soil pore space geometry. The objectives of this study are to: 1) model primary processes governing aggregate fragmentation and rejoining following tillage; and 2) quantify effects of these phenomena on evolution of soil pore space and hydraulic properties. Soil swelling and fracture properties will be used to predict likelihood and extent of fragmentation due to cyclic and nonuniform wetting and drying. The theory of capillary-induced sintering of aggregated media will be used to model the fusing of wet soil fragments into larger and more stable structural units. The resulting till-dependent soil pore size distributions coupled with statistical models of hydraulic conductivity provide a means for quantifying changes in soil transport properties. The results should greatly enhance our understanding of the evolution of structure and associated hydraulic properties in tilled soils leading to improved precision management capabilities which are crucial to sustainable intensive agriculture.

9700970 Phloroglucinol Producing Pseudomonads in Take-All Suppressive Soils
Weller, D.M.; Thomashow, L.S.; Raaijmakers, J.M. **Grant 97-35107-4804**

USDA Agricultural Research Service
Root Disease and Biological Control Research Unit **$255,000**
Pullman, WA 99164-6430 **3 Years**

Take-all is the most destructive root disease of wheat worldwide. There are no varieties resistant to take-all, and chemical controls are limited. The need for U.S. Agriculture to become more sustainable has necessitated the development of alternate methods to control root diseases. Take-all decline (TAD) is the spontaneous decrease in the severity of take-all occurring in fields with monoculture wheat after a severe outbreak of the disease. This natural biocontrol of take-all is an example of a disease-suppressive soil. Such soils provide the first line of plant defense against infection by soilborne pathogens. In four soils in Washington State, TAD occurred because of the build-up of a specific group of bacteria known as fluorescent pseudomonads, which produce the antibiotic 2,4-diacetylphlorgoglucinol (Phl). The antibiotic is produced in very minute quantities in sites on roots where the take-all pathogen infects. This is the first time that the molecular basis of any suppressive soil has been defined. The objectives of this proposal are to determine if Phl-producing pseudomonads are responsible for TAD in all U.S. Agricultural soils; to quantify the population dynamics of Phl-producers on wheat and other crops in the field; and to determine the genotypic and phenotypic structure of Phl-producing populations occurring on wheat during monoculture. The findings from this study are expected to greatly expand both the understanding of disease-suppressive soils and their use in systems of sustainable agriculture.

9700808 Ecotypic Variation in Ectomycorrhizal Fungi from Serpentine Soils
Cumming, J.R.; Panaccione, D.G. **Grant 97-35107-4374**

West Virginia University **Strengthening Award**
Department of Biology **$190,000**
Morgantown, WV 26506-6057 **3 Years**

Mycorrhizal fungi form a uniquely beneficial symbiotic relationship with the roots of trees. These fungi increase nutrient uptake and environmental stress tolerance of their tree hosts. To date, little is known of the specialization within these fungi with respect to soil chemical characteristics. The overall goals of this research are to determine the extent to which the chemistry of soils influences populations of these fungi and to elucidate the mechanisms of stress tolerance in these fungi that function to protect trees from toxic metals in the environment. Naturally-occurring serpentine soils in Lancaster County, PA, characterized by elevated magnesium and nickel concentrations, will be used in these investigations. Genetic studies will utilize DNA fingerprinting to analyze biodiversity in populations from serpentine and non-serpentine environments. Physiological studies will investigate metal tolerance systems in fungi, including those based on metal detoxification in the soil and within fungal tissue. Finally, the capacity of fungi to confer metal tolerance to Virginia pine seedlings will determined. Together, these studies will indicate whether soil factors are influencing biodiversity in these fungi, what physiological mechanisms are selected for in these soils, and may lead to the identification metal tolerant individuals. Although serpentine soils are relatively rare in the United States, these sites provide a unique opportunity to study the biodiversity and physiology of stress tolerance in mycorrhizal fungi. Isolation and identification of mycorrhizal genotypes tolerant of metals may provide an aid to the reforestation and reclamation of mined or pollution-contaminated lands.

WATER RESOURCES ASSESSMENT AND PROTECTION

Panel Manager - Dr. Thomas A. Doerge, University of Arizona
Program Director - Dr. Berlie Schmidt

Land management and water use practices and policies affect water quality and availability, and habitat quality. Research is needed on the effects of farming, range, forestry, and other agricultural practices on our water resources, and to develop effective and economically feasible water pollution prevention or remediation practices.

Innovative research is supported on: (a) the distribution, fate, and transport of water-borne contaminants of agricultural origin; (b) the role of soil heterogeneity, hydrology, and landscape position on water quality; (c) management and remediation practices and/or technologies; (d) and the social, economic, policy, and environmental impacts of agricultural land management and water contamination remediation practices.

The Water Resources Assessment and Protection Program was not competed in FY 1997 due to limited funds. A number of highly meritorious proposals reviewed in FY 1996 were not supported due to limited funds in FY 1996. Some FY 1997 funds were made available to support five of these proposals.

9604066 Development of a Nitrogen Management Scheme for Precision Vegetable Production
Upadhyaya, S.K. **Grant 97-35102-4208**

University of California, Davis
Biological and Agricultural Engineering Department **$200,000**
Davis, CA 95616-5294 **3 Years**

The goal of this research is to investigate environmental and energy benefits of applying site-specific amounts of fertilizer in vegetable production systems. The irrigated, processing tomato crop is selected in this study because of its economic importance to California as well as its high nitrate fertilizer requirements. All tests will be conducted in two loamy fields cultivated in Winters, CA. A typical crop rotation scheme consisting of tomato ~ winter wheat ~ fallow ~ tomato will be used in this study. The texture/compaction sensor developed at UC Davis will be used to relate the variability in soil texture/compaction values to variability in infiltration characteristics in the field. A soil fertility management map will be developed based on the variability in crop yield as a function of the variability in various inputs such as soil texture/compaction level, soil fertility level, soil organic matter content, soil salinity level, vegetative index, etc. A map-controlled variable rate fertilizer management scheme will be implemented to examine the potential benefits of reducing the nitrate fertilizer application rate while maintaining tomato yield on nitrate leaching. The outcome of this research will quantify the benefits of precision agriculture in reducing environmental contamination while conserving natural resources in irrigated agriculture.

9604089 Specific Sorption in Soil Organic Matter: Characterization and Effect on Kinetics
Pignatello, J.J.; Xing, B. **Grant 97-35102-4201**

Connecticut Agricultural Experiment Station, New Haven
Department of Soil and Water **$250,000**
New Haven, CT 06504-1106 **3 Years**

The sorption (adsorption or absorption) of pesticides and other organic chemicals to soil particles is an underlying process affecting their transport and bioavailability. It is well known that organic chemicals sorb preferentially to the soil organic matter (SOM) fraction, yet the mechanism is incompletely understood. The commonly accepted “partition” model of sorption holds that molecules "dissolve" in the three-dimensional solid phase of SOM. The partition mechanism fails, however, to explain certain behaviors, such as the nonlinear effect of sorbate concentration, competition when multiple chemicals are present, and slow desorption rates. We hypothesize that two mechanisms take place concurrently: a nonspecific solid-phase dissolution process, and an adsorption-like process in which molecules fit into specific internal sites in the SOM. A major objective of this research will be to define the nature of the sites using nuclear magnetic resonance (NMR) spectroscopy and studies that examine the influence of chemical and SOM properties on sorption behavior. Another objective is to determine whether chemicals become entrapped in these sites. The studies will involve various soils with agricultural and other chemicals. The results are expected to assist in efforts to predict the movement of chemicals in soil and groundwater, their long-term persistence, the bioavailability with respect to soil bacteria, plants, and soil-borne pests, and the risk to human health and the environment of contaminated soil.

9604194 Steroids in Runoff Water from Pastures and Hayfields Amended with Broiler Litter
Hartel, P.G.; Cabrera, M.L. **Grant 97-35102-4209**

University of Georgia, Athens
Department of Crop and Soil Sciences **$81, 239**
Athens, GA 30602-7272 **2 Years**

Recent evidence suggests that environmental sources of estrogen and testosterone are implicated in a drastic reduction of sperm counts in Western men and in widespread disorders in a variety of wildlife. We will investigate broiler litter as a source of estrogen and testosterone. In 1994, the U.S. poultry industry produced over 10 billion kg of broiler litter, 90% of which was applied to pastures and hayfields. Because broiler litter contains approximately 65 ng of estrogen and 133 ng of testosterone per g of dry weight, this litter has the potential to contribute hundreds of kilograms of hormones to the environment. In our two-year study, we will determine the concentrations of estrogen and testosterone in runoff and subsurface drainage from pastures and hayfields amended with broiler litter. Our approach is to use an existing field site (located near Eatonton, Georgia) originally designed to assess nitrogen and phosphorus losses from broiler litter-amended pastures. Each of the seven field plots is sufficiently large (0.6 hectare) to permit determination of true "edge of field" losses. Our preliminary data suggest that concentrations of >1,000 ng of estrogen and testosterone per liter of runoff water can occur. The proposed work evaluates a potential major source of hormones to the environment that has not been studied before.

9604087 Soil Heterogeneity and Multi-Scale Transport: Field Experiments and Network Models
Ellsworth, T.R.; Mayer, S.; Boast, C.W. **Grant 97-35102-4216**

University of Illinois, Urbana-Champaign
Department of Natural Resources and Environmental Sciences **$218,761**
Urbana, IL 61801 **3 Years**

The overall goal of the proposed research is to gain understanding of the influence of soil heterogeneity on solute transport over a range of scales. This is an essential prerequisite for assessment, prevention, and remediation efforts. Our specific objectives are to develop candidate formulations of a new model based on pore scale networks and to evaluate their performance using experimental data; to experimentally determine the heterogeneity of transport properties over a plot-to-field scale continuum; and to provide a model to describe heterogeneous transport over such a range of spatial scales. Existing models are far from perfect; the assumptions underlying classical models have been demonstrated to be invalid for most soils. Alternative approaches relying on numerical solutions of discrete transport pathway approximations are prohibitive; the numerical work required to represent heterogeneous soils exceeds available computer resources. The proposed pore-scale network model bridges this gap in existing transport models in that it is versatile enough to describe flow and transport through heterogeneous porous media while it is conceptually simple and allows for fast solutions. This approach is well positioned to accept additional complications, such as unsteady flow, sorption, biodegradation and multiphase flow.

The primary purpose of the combined experimental and modeling effort is to develop a conceptual tool for relating information which is obtained at a plot scale to processes which occur at the field scale. Five field experimental data sets will be used in accomplishing our objectives: three completed, one requiring completion of chemical analysis, and one constituting the bulk of the experimental work proposed here. The first four of these and studies by other research groups suggest that much of the influence of soil heterogeneities on transport properties is manifested at the plot scale. The resulting potential for scaling up motivates the fifth, large-scale experiment, which will be used to test the model's upscaling ability.

9604157 Assessment Tool for Evaluation of NPS Pollution Control Policies in Watersheds
Bosch, D. J.; Wolfe, M.L.; Stone, N.D.; Pease, J.W.; Dillaha III, T.A.; Heatwole, C.D. **Grant 97-35102-4202**

Virginia Polytechnic Institute and State University
Department of Agricultural and Applied Economics **$250,000**
Blacksburg, VA 24061-0401 **3 Years**

The effectiveness of policies to control agricultural nonpoint source (NPS) pollution depends upon their farm level implementation as well as farm economic and physical characteristics. The goal of the research is to develop an integrated watershed assessment tool to evaluate the water quality and economic impacts of alternative policies to control agricultural NPS pollution. The research will account for spatial physical and economic diversity within watersheds in evaluating and selecting between alternative NPS pollution control policies.

Specific research objectives are to develop a watershed assessment tool to quantify the water quality protection and economic effectiveness of alternative NPS pollution control policies; to implement the tool in a way that allows additional scientific models and information tools to be incorporated into the assessment tool as needed; and to demonstrate the use of the tool for evaluating two alternative nutrient management policies in a watershed. The tool will consist of integrated modules for resource inventory, simulation of NPS pollution, farm planning, and economic analysis of alternative strategies to control NPS pollution. The resource inventory module includes geographic information system (GIS) data layers that describe farm characteristics including soil types and location. The farm planning module determines what farm practices could be implemented in response to policy. The NPS pollution simulation module predicts the impacts on water quality of farm management decisions and resource constraints. The economic module assesses economic impacts of policies. The watershed assessment tool will be applied to a Virginia watershed to evaluate mandatory and targeted nutrient management planning.